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PROGRAM

March 6, 2007

Mr. Brad Schultz
Environmental Senior Scientist
Air Quality Program
South Dakota Department of Environment and Natural Resources
Joe Foss Building
523 East Capitol
Pierre, SD 57501-3182

RE: Proposed Ambient Air Monitoring Plan
Basin NextGen Project Ambient Monitoring Plan

Dear Mr. Schultz,

Thank you for your timely review of the Basin NextGen Project Ambient Monitoring Plan. On behalf of our client, Basin Electric, Inc. ENSR is submitting revisions in response to your requests and comments. Based on your letter dated January 26, 2007 we are enclosing revised monitoring plans in response to your numbered comments as follows (responses are provided in italics after each comment):

1. EPA has revised the monitoring regulations in 40 CFR Part 58 amended in October of 2006. The Plan must be updated to include any difference in quality assurance and reporting procedures created when EPA revised 40 CFR Part 58. One change made by EPA was the merging of Part 58, Appendix B into Appendix A. All references to Part 58 Appendix B must be changed to Appendix A.

The plan has been updated to be consistent with 40 CFR 58 Appendix A.

2. The plan does not include the sampling for PM2.5 which could be an issue later. Sampling for PM2.5 at this time would eliminate one potential item that someone could use to challenge a future permit application. Also EPA could require the testing for PM2.5 by the time a permit application is submitted and no data would be available. Setting up a second sampling site at a later date to collect this data would be more costly later and could set back the permitting process for a year. DENR requests that Basin Electric consider collecting PM2.5 data as part of this monitoring project.

Basin Electric is proposing a separate PM2.5 monitoring program that involves a continuous monitor in accord with California Air Resources Board monitoring protocols. We are not proposing to monitor PM2.5 with the reference method due to the extreme sensitivity of sample handling and retrieval.

3. **Section 1.0 Introduction**

- The introduction refers to the project location as near Pierre. I would suggest changing this to "Central South Dakota" in the entire document.

The location of the site is now given as central South Dakota and it's relation to Pierre has been clarified

4. **Section 2.0 Source Environment Description**

- The map in Figure 2-1 does not show the current location of the air monitoring site for the project. Please replace this map with the correct location and include a topography map of the area surrounding the site.

Figure 2-1 has been replaced with a correct map. A topography map has been added to section 3.

- Land Use Section 2.3 needs to include a description of the land use in area around the monitoring site within 2 kilometers. In general there is no irrigated cropland in this part of Potter County. The only irrigated cropland is in the western edge of the county along Missouri River/ Lake Oahe.

The land use description has been changed to being in the CRP program.

- Fourth paragraph in 2.2 Climate section: Seasonal wind directions in South Dakota are generally out of the northwest in the winter and southeast in the summer. See the attached wind rose showing the data from the Huron Airport weather station.

The seasonal wind directions have been updated.

- Section 2.5 Existing Sources: Aberdeen, is about 70 miles away and is the closest location that would have permitted air quality sources emitting gaseous pollutants. Closest permitted source for PM10 is in Gettysburg. The largest source of PM10 concentrations would be fugitive dust from farming activities in this area. Distance and direction to the nearest acreage under active tillage should be included in this section.

The existing sources section has been updated with the above information. We will document the distance to nearby tillage as the project is underway.

5. **Section 3.0 Monitoring Program Description**

- Should Section 3.0 be titled Monitoring Site Description?

The title for section 4 has been updated.

- Section 3.1 should include a proposed date of the beginning and end of the sampling project.

This information has been added.

- We believe more details should be included in section 3.2 to discuss the reasons the selected monitoring site is representative of all the proposed sites for the power plant.

Additional information has been added.

- Page 3-3, 1st full paragraph states the sampling schedule for PM10 will be every sixth day. This meets the minimum sampling schedule but we would suggest increasing this to every 3rd day to increase the number of sampling days used to compare the levels to the PM10 standard. The co-located monitor will also be running on an every 6th day schedule so there could be as many precision checks as sampling data.

The monitoring plan is consistent with the requirements for PSD monitoring. As this is a green field area PM10 levels are anticipated to be very low and so additional data should not be necessary for making comparisons to NAAQS.

- Page 3-3: The sections last sentence in the paragraphs indicates three monitoring sites in the network. It is our understanding that only one site is planned.

This error has been corrected.

- Table 3-1 has UTM coordinates for the sampling site. It appears this location is #9 of the proposed sites. Is the monitoring site at site #9 or #8? The map in Figure 3-2 shows proposed site #9.

The UTM coordinates are correct and consistent with the maps in figures 2-1 and 3-2.

- Table 3-1 should include your AQS number for the site. We have assigned the following number for your site: **46-107-0101**

The AQS number has been added.

- Added a reference in this section for adding a final Appendix to the plan showing the actual measurements demonstrating the station meets the network design criteria found in 40 CFR Part 58 Appendix D including general pictures of the sampling station, 8 main wind directs from the shelter, and pictures of the equipment setup inside of the shelter.

As requested, an addendum will be submitted to SD DENR with photos of the sampling station as built including the views in the 8 cardinal directions, the sampling station and equipment. However, it is our understanding that Appendix D of 40 CFR 58 does not strictly apply to PSD monitoring and therefore there is no need to demonstrate compliance with its contents. The addendum will also identify the distance to the nearest tillage.

6. **Section 4.0 Monitoring Program Description**

- Please indicate in each section the EPA reference or equivalent method number for each monitor type.

Reference Methods have been added to Table 4-1.

-
- Table 4-1 indicates the use of a Wedding model monitor. From the previous information and in 4.1.4 it appears the project will use a GMW high volume monitor with a critical flow device. The department does not approve the use of a Wedding style monitor for PM10 sampling.

The project is using a Tisch TE-6070V Volumetric Flow Controlled PM10 monitor

- This section should include a paragraph on how the shelter internal temperature will be measured and how records will be kept to show compliance with the operational temperature range.

This has been added to section 4.5.

7. **5.0 Station Operational Procedures**

- It is my understanding the meteorological parameters will be collected using a 100 meter tower. Both sections 5.2.1 and 5.2.2 indicate the tower will be 60 meters high.

These errors have been corrected.

- This section should indicate the range and estimated sampling height for each of the criteria monitoring parameters.

These values are included in table 4-1.

- This section should include a section PM10 filter weighing listing who will be performing the filter weighing for the PM10 and how operation and quality assurance standards will be met.

This has been added in a new section 4.4.

- Table 5-4 lists the Accuracy Goals for the air monitoring project. Two of these goals are different than required by our EPA oversight contact at EPA Region VIII.

Table 5-4 is now table 6-1

1st Continuous Gas Analyzers Zero/Span checks +/- 15% of span drift and zero check of +/- 0.015 ppm or 3% of full scale. These should be control limits (when operation of the analyzer needs to be reviewed to determine if data is valid). Most if not all of your collect hourly sample concentrations for sulfur and nitrogen dioxides are going to less than 0.015 ppm. An error rate of 15% and a zero error level of 0.015 would negate any concentrations you may collect. Because of the clean air conditions expected in this region you would suggest a limit of +/- 10% span drift and +/- 1% of full scale for zero.

Accuracy goals are associated with audit tolerances not zero/span checks. Furthermore the accuracy goals of PSD monitoring are determined by the objectives of the program—determining compliance with NAAQS standards—not ambient conditions. Our accuracy goals are to our knowledge consistent with all regulations pertaining to PSD monitoring.

2nd Particulate Samplers Page 5-8, flow rate standard of +/- 7%. EPA requires that we have an accuracy level for flow rate verifications and audits on PM10 monitors to be no more than +/- 4%. In our use of VFC units in PM10 monitors this goal can be met without a problem. Please make this change to the table.

The audit tolerance for the flow rate of the sampler and therefore the accuracy objective is actually +/-10% (Quality Assurance Handbook, Vol. II, part II page 90). The +/-4% acceptance limit relates to calibrations.

Shelter Temperature – Please add the control range of 20 to 30 degrees C for the shelter internal temperature to this table.

While an important quality control requirement of the program that is tested for in the validation routines, maintaining the shelter temperature in the specified control range is not an accuracy objective and therefore we feel that it does not belong in this table. See comment in Section 4.5.

8. **6.0 Quality Assurance Plan**

- This part of the plan will have to indicate the statistical assessments as listed in 40 CFR Part 58 Appendix A 4.0 as amended October 17, 2006 in the frequency required of Section 5.2 of the same appendix.

This information is included in the revised sections 7.35 and 7.4

- Section 6.1 again shows 15% on precision and accuracy for the gaseous analyzer. The regulations indicate equal to or less than 7% (percent difference) for SO₂, NO₂, and O₃ precision checks.

The 7% accuracy and precision objective in 40 CFR 58 only applies to O₃. We are unaware of any other regulations that specify accuracy and precision objectives of 7% for SO₂ or NO₂. If SD DNER can provide us with the reference that indicates 7% accuracy and precision objectives for SO₂ and NO₂, than we will update our monitoring plan accordingly.

- Section 6.1 does not show what the precision and accuracy acceptance criteria for PM₁₀. Please add the following acceptance criteria: Precision for PM₁₀ is 5 micrograms per cubic meter (ug/m³) on samples with concentrations less than 80 ug/m³ and 7% percent difference on samples greater than 80 ug/m³. Source: 40CFR Part 50, Appendix J 4.0 (2005).

This addition has been made.

- Table 6-1 has been changed in the revised CFR Part 58 Appendix A. Please update this table with the audit ranges. See previous discussion on acceptance criteria.

Table 6-1 (now table 6-2) has been updated to be consistent with our understanding of CFR Part 58 Appendix A based upon our recent interpretations of the rule with Steve Hoelscher of the Nevada Division of Environmental Protection.

- Section 6.5.1 Flow calibration of a volumetric flow control device may need only a one point check using a certified flow orifice against the lookup table flow.

This section pertains to calibrating the flow rate on the sampler, not auditing the flow rate. A multi-point calibration is always superior to a single point calibration.

- Section 6.5.1 should detail the PM10 Flow Verification check, acceptance criteria, and frequency required by Appendix A in 40 CFR Part 58.

Section 6.5.2 has been updated to clarify our PM10 audit procedures. We plan on performing a full flow rate audit on a quarterly basis. We will be submitting the results of the quarterly audits to meet both the flow rate verification and semi-annual audit requirements of Appendix A. As a full audit is a more conservative test of the instrument performance this should be an acceptable way to show compliance with the accuracy standards.

- Table 6-2 the PM10 flow audit acceptance criteria at +/-10%. I believe these checks should also be at +/- 4%.

See above note, +/-10% is correct.

- Appendix A of 40 CFR Part 58 requires that PSD monitoring plans provide for the participation in EPA's National Performance Audit Program as detailed in Section 2.4. The quality assurance item needs to be added to your plan.

We are happy to participate in the NPAP program if SD DNER can provide equipment in a timely and efficient manner. However, Appendix A of 40 CFR Part 58 requires that "the monitoring plan provide for the implementation of independent and adequate audits of all monitors" not participation in NPAP. Participation in the EPA NPAP and PEP programs is one way to meet this requirement. Our monitoring plan provides for independent audits of the monitoring site which in all previous cases, including plans approved in 2007, been deemed adequate.

- DENR would like to conduct an audit of the monitoring site shortly after startup and sometime in the middle of final sampling quarter of the project. Please add these DENR audits to the monitoring plan.

The audit will include but not limited to gas analyzer checks, flow checks, meteorological parameter checks, and review of onsite records. During the first DENR audit trip we would want to review the certification records for the calibration and audit devices being used on-site.

DENR is welcome to provide additional audit equipment to be used by our contracted independent auditor and to be present during our regularly scheduled audits. As these audits will not be used in our data validation and assessment efforts we would not include them in the monitoring plan.

9. **7.0 Data Validation, Data Processing, and Reporting**

- Section 7.2.1 does not list all the filter conditioning criteria. Please add it in this section or in one of the previous sections.

This information is included in the referenced SOP.

- Section 7.3.5 Data Capture, Precision, and Accuracy – The ENSR SOP 2990-001 will need to be updated following the requirements in Appendix A of 40 CFR Part 58 as amended on October 17, 2006.

ENSR SOP 2990-001 has been updated to be consistent with the new appendix A of 40 CRF Part 58

- Section 7.4 Data Reporting - DENR would like an electronic file copy of the raw data including voided data codes for each quarter or at the end of the project in Excel format for SO₂, NO₂, Ozone, and PM₁₀. For the continuous monitors the file should include date, hour, and concentration. For the PM₁₀ monitors it should include date and 24-hour concentration for each sampling day including co-located data. The file should also include raw data results from flow verification, precision, and accuracy checks to include date, check readings for the audit device and monitor. The electronic data files will be kept by DENR in house and will not be made available to the public until after Basin has submitted its application for a new power plant. After that time DENR will load the data results to the EPA national database.

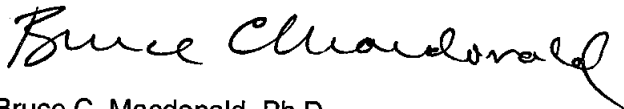
This following bullet has been added under section 7.4: Digital copy of validated data and QC data contained in the quarterly report;

10. In general changes will need to be made to the standard operating procedures listed in the Basin the Appendix of the NextGen Ambient Monitoring Plan so the requirements are consistent with the amended 40 CRF Part 58.

The SOPs and the monitoring plan have been updated to be consistent with the new appendix A of 40 CFR Part 58

Enclosed are two updated copies of the Ambient Air Monitoring Plan for this project. Please review and provide any comments as soon as you can. Your expedited review is greatly appreciated. You may call Bruce Macdonald or Vince Scheetz at 970-493-8878. We look forward to hearing from you regarding this submittal.

Regards,



Bruce C. Macdonald, Ph.D.
Senior Program Manager



Vincent R. Scheetz, CCM
Air Resources Department Manager

Ref: 02450-017-513
Enclosures

cc: Chris Miller, P.E., Basin Electric Power Cooperative

Prepared for:
Basin Electric, Inc.

Basin NextGen Project

Ambient Monitoring Plan

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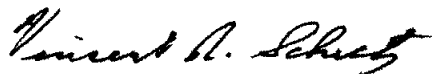
Prepared for:
Basin Electric, Inc.

Basin NextGen Project

Ambient Monitoring Plan



Prepared By



Reviewed By

ENSR Corporation
March 2007
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1.0 Introduction

Basin Electric, Inc. (Basin) is the owner and operator of the proposed Basin NextGen Project located in central South Dakota. In support of the planned construction and installation of power plant sources, including coal-fired boilers, Basin has retained ENSR Corporation (ENSR) to install and operate an ambient air quality and meteorological monitoring station near the proposed project location. The primary objectives of this monitoring study are:

- To fulfill pre-construction air monitoring potentially required under Prevention of Significant Deterioration (PSD) permitting rules at the site of the proposed source;
- To obtain baseline ambient air quality concentrations; and
- To provide a comprehensive on-site database for use in dispersion modeling using AERMOD and CALPUFF.

To meet these objectives, Basin and its air monitoring consultant, ENSR, would install an instrumented meteorological tower and a fully equipped air quality monitoring shelter at the monitoring site. The monitoring station is to be located in the vicinity of the proposed facility. The air quality and meteorological station would be located near existing electrical distribution lines alternating current (AC) power for shelter, air quality instrumentation and meteorological tower. The air quality and meteorological monitoring systems are described in more detail in Chapter 3.0.

All monitoring will be performed in accordance with South Dakota and U.S. Environmental Protection Agency (USEPA) ambient monitoring guidance. This monitoring plan has been developed following guidance provided by the USEPA publication *Ambient Monitoring Guidelines for Prevention of Significant Deterioration* (USEPA 1987). Additional guidance also was obtained from the following:

- Code of Federal Regulations (CFR) Title 40, Chapter I, Subchapter C, Part 58, Ambient Air Quality Surveillance;
- Meteorological Monitoring Guidance for Regulatory Modeling Applications (USEPA 2000);
- Quality Assurance (QA) Handbook for Air Pollution Measurements, Volume I, A Field Guide to Environmental Quality Assurance (USEPA 1994a);
- Quality Assurance Handbook for Air Pollution Measurements, Volume II, Part 1 (USEPA 1998);
- Quality Assurance Handbook for Air Pollution Measurements, Volume II, Ambient Air Specific Methods (Interim Edition) (USEPA 1994b); and
- Quality Assurance Handbook for Air Pollution Measurements, Volume IV, Meteorological Measurements (USEPA 1995).

Chapter 2.0 of this monitoring plan describes the source environment east of Pierre, South Dakota, in terms of the topography, land use, and climate. A description of the monitoring site and justification for the selection is documented in Chapter 3.0. Chapter 4.0 summarizes the sampling program with details on the parameters to be measured, instrument manufacturer and model number, probe height, sampling frequency, and instrument response range. Routine operational procedures for the Basin ambient air quality and meteorological monitoring program are discussed in Chapter 5.0. This chapter also emphasizes the quality control features of the network operational procedures, including detailed summaries of the calibration procedures to be employed in this program. Chapter 6.0 focuses on QA aspects of the program and serves as the formal QA plan for the Basin monitoring program. This chapter also discusses the procedures and policies included in the program to ensure that USEPA and the South Dakota Department

of Environment and Natural Resources (SDDENR) QA guidelines are met, including enforcement of quality control procedures, use of certified standards traceable to the National Institute of Standards and Technology (NIST), and independent audits of program performance. Chapter 7.0 describes the data management aspects of the monitoring program including data validation, data processing, and data reporting.

Supplementary technical data are presented in the appendices. The appendices include standard ENSR project forms (Appendix A); and ENSR's Corporate Statement of Quality Assurance Policy (Appendix B). Relevant ENSR Standard Operating Procedures (SOPs) for equipment and methods to be used in this program are in Appendix C; and manufacturer's specifications for the air quality analyzers and meteorological monitoring instrumentation and sensors are included in Appendix D.

In cases of conflict between a SOP and the body of the Plan exclusive of the appendices, the body of the Plan will be operative and the SOP will be subject to the body of the Plan.

2.0 Source environment description

2.1 Topography

The proposed Basin Next Generation Power Project will be located in central South Dakota.

Rolling plains are the main feature of South Dakota, varying from nearly level land to hilly ridges, and increasing in elevation from the eastern border to the western edge of the state. The state is bisected by the Missouri River which flows in a southerly direction to Pierre and then turns to the south-southeast. East of the Missouri River the land is primarily flat with numerous small ponds and lakes.

The location of the site is technically in a region recognized as sub-humid, but is very near the Missouri River, which is the arbitrary border of the adjacent climate region classified as semi-arid. The Basin monitoring station would be located in Potter County in central South Dakota approximately 50 miles northeast of Pierre. **Figure 2-1** is a regional map showing the location of the monitoring site.

2.2 Climate

The climate of the plains is comparatively uniform from place to place, with characteristic features of low relative humidity, abundant sunshine, light rainfall, moderate to high wind movement, and a large daily range in temperature. Summer daily maximum temperatures are often 95 degrees Fahrenheit (°F) or above, and 100°F temperatures have been observed at all plain stations. The highest temperatures in South Dakota occur in the central plains, and sometimes exceed 115°F. The usual winter extremes in the plains are from zero to 10°F or 15°F below zero.

Warm, moist air from the south moves into South Dakota most frequently in the spring. As this air is carried northward and westward to higher elevations, the heaviest and most general rainfalls of the year occur over the eastern portions of the State. Frequent showers and thunderstorms continue well into the summer. At times during the summer, winds shift into the southwest and bring hot, dry air over the State from the hottest weather of the year over the eastern plains, but such hot spells are usually of short duration.

An important feature of the precipitation in the plains is the large proportion of the annual total that falls during the growing season – 70 to 80 percent during the period from April through September. Summer precipitation in the plains is largely from thunderstorm activity and is sometimes extremely heavy. Strong winds occur frequently in winter and spring. These winds tend to dry out soils, which are not well supplied with moisture because of the low annual precipitation. During periods of drought, high winds give rise to the dust storms which are especially characteristic of the southeastern plains.

At this latitude, the prevailing winds are from the west. However, the high plains are characterized by a seasonal wind pattern that is essentially from the northwest in the winter and from the southeast in the summer. The monitoring program is designed to measure the local air flows in the vicinity of the proposed power project.

Thunderstorms are quite prevalent in the eastern plains during the spring and summer. These sometimes become severe, with possibility of hail damage to crops. Tornadoes are relatively infrequent over the eastern plains, where fatality rates and property loss rates are lower than in states farther east. Other severe storms include winter blizzards that occasionally occur on the northern plains.

Annual precipitation at Pierre is about 19 inches per year. Precipitation occurs during all months of the year, and snow is common during the autumn, winter, and spring seasons. Each of the months May through July receives more than 2 inch of precipitation, on average. June is the wettest month, receiving more than 3.5 inches on average.

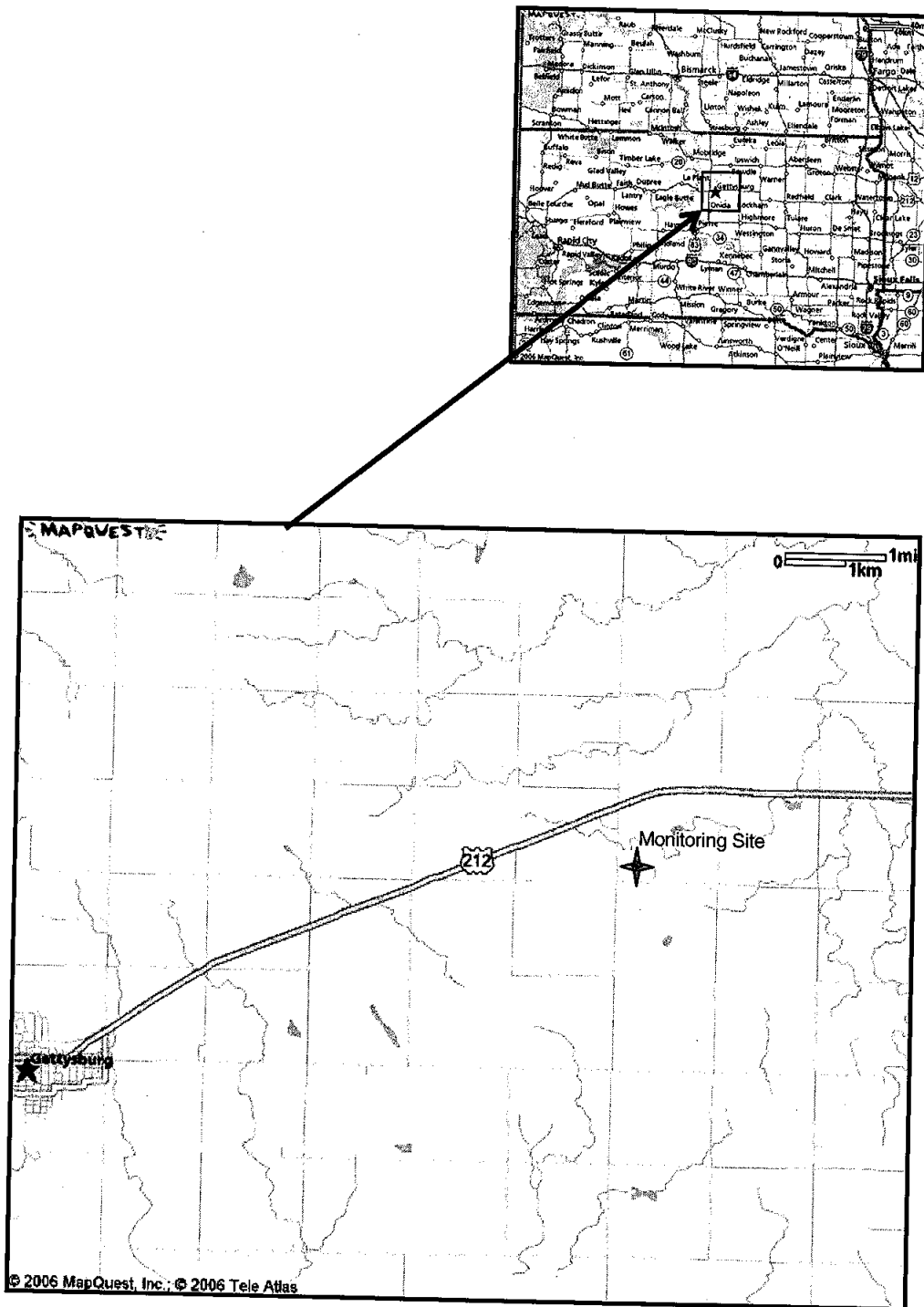


Figure 2-1 Regional map with Basin monitoring site location

The average daily maximum and minimum temperatures in January are 26.8°F and 6.1°F, respectively, for a range of 20°F. In July, the average maximum and minimum are 89.2°F and 61.7°F. **Table 2-1** shows the period of record (1948 to 2005) average monthly and annual maximum and minimum temperatures as well as average precipitation, snowfall, and snow depth.

Table 2-1 Monthly climate summary for Pierre, South Dakota: 1948 to 2005

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Maximum Temperature (°F)	26.8	33.3	43.1	59.3	70.7	80.8	89.2	88.0	77.0	63.0	44.5	31.8	59.0
Average Minimum Temperature (°F)	6.1	12.1	21.5	34.3	45.6	55.6	61.7	59.9	48.9	37.0	23.3	12.0	34.8
Average Total Precipitation (inches)	0.47	0.60	1.04	1.88	2.95	3.56	2.44	1.88	1.54	1.30	0.59	0.50	18.75
Average Total Snowfall (inches)	5.1	6.3	6.6	3.0	0.2	0.0	0.0	0.0	0.0	0.8	4.0	5.6	31.6
Average Snow Depth (inches)	2	2	2	0	0	0	0	0	0	0	1	2	1

Source: High Plains Regional Climate Center 2006.

2.3 Land use

Land use in the vicinity of the proposed Basin power project is primarily grassland maintained as part of the Conservation Reserve Program.

2.4 Air quality

The proposed Basin Next Generation site area in Potter County is designated as attainment or unclassifiable for all criteria pollutants; that is, existing background concentrations for all criteria air pollutants are less than the maximum allowable ambient concentrations under South Dakota and federal regulations. Areas where insufficient data are available to make an attainment status designation are listed as unclassifiable and are treated as being in attainment for regulatory purposes.

2.5 Existing sources

The proposed Basin ambient air monitoring site is a relatively pristine area with no significant stationary sources of any criteria pollutants. Agriculture does contribute to particulate emissions but gaseous pollutants are mostly insignificant. The nearest larger sources of gaseous and particulate pollutants are located in Pierre about 50 miles to the southwest. Fugitive dust may also occur from traffic on the local dirt roads and occasional windstorms in the area. The nearest permitted air quality sources of gaseous pollutants are about 70 miles away in Aberdeen. The closest permitted source for PM₁₀ is in Gettysburg.

3.0 Monitoring description

3.1 Program objectives

The proposed Basin monitoring program is designed to fulfill specific regulatory requirements that relate to the USEPA PSD program. Pre-construction monitoring requirements that relate to the PSD program will be satisfied through the implementation of this air monitoring program. The USEPA's Ambient Monitoring Guidelines for PSD require that one full year of data used for new permits or for modifications to existing permits be collected within the past 3 years.

The objectives of the recommended ambient air monitoring program are to:

- Fulfill pre-construction meteorological monitoring potentially required under PSD permitting rules at the site of the proposed source;
- To obtain baseline ambient air quality concentrations; and
- Provide a comprehensive on-site meteorological database for use in dispersion modeling, including AERMOD and CALPUFF.

To meet these objectives an air quality station and a tall meteorological tower would be established to collect meteorological and air quality data at the proposed Basin location in the vicinity of Pierre, South Dakota. A diagram of the site shows the relative locations of the air quality shelter and meteorological tower (Figure 3-1). The site is proposed to be located in the vicinity of the proposed Basin Next Generation Power Project site. The site would include a 100-meter (m) meteorological tower with wind instruments at 3 levels. The site will be operated from April 1st of 2007 through the March 31st of 2008 with the exact collection period determined by when weather conditions permit construction.

The Basin meteorological tower is proposed to monitor the following parameters:

- 100-m horizontal wind speed, wind direction, and wind direction standard deviation (sigma-theta);
- 100-m vertical wind speed and vertical wind speed standard deviation (sigma-w);
- 50-m horizontal wind speed, wind direction, and wind direction standard deviation (sigma-theta);
- 50-m vertical wind speed and vertical wind speed standard deviation (sigma-w);
- 10-m horizontal wind speed, wind direction, and sigma-theta;
- 10-m vertical wind speed and sigma-w;
- Ambient temperature at 2 m, 10 m, 50 m and 100 m;
- Temperature difference between the 100 m and 50 m, 50 m and 10 m, and 10 m and 2 m levels;
- Solar radiation;
- Relative humidity (RH);
- Precipitation; and
- Barometric pressure.

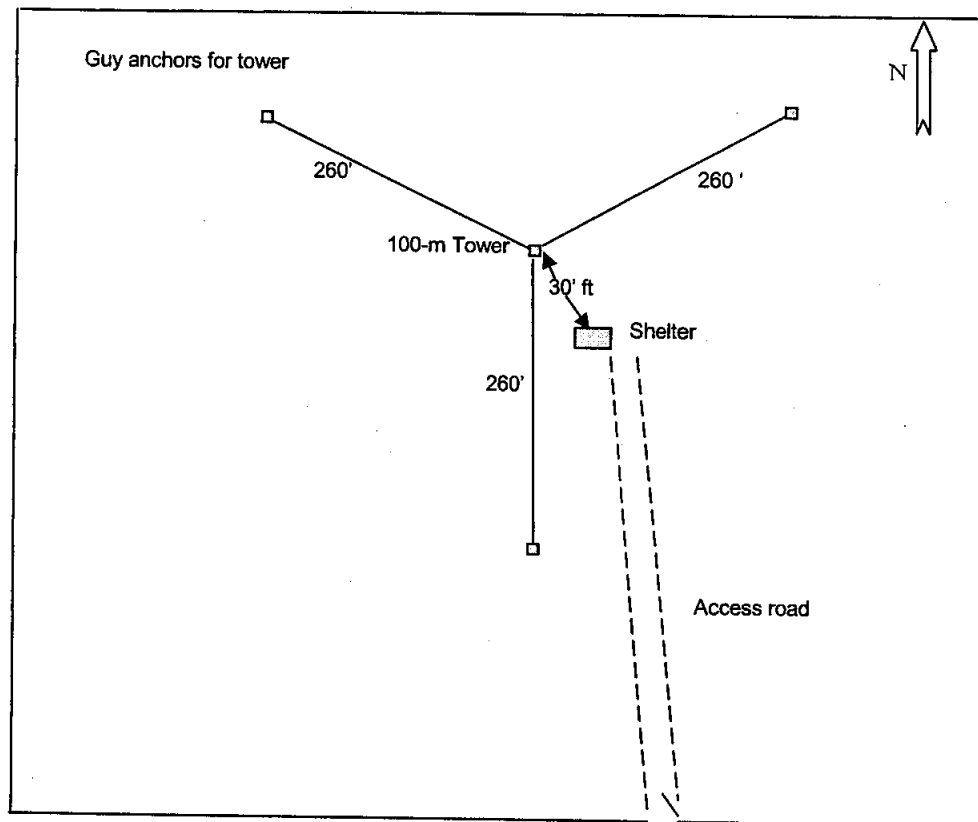


Figure 3-1 Site Layout for the Basin Ambient Monitoring Program (Schematic not to Scale)

Air quality parameters to be measured include the following:

- Oxides of nitrogen (NO_x, nitrogen dioxide [NO₂], and nitric oxide [NO]);
- Sulfur dioxide (SO₂);
- Ozone (O₃); and
- Particulate matter (PM) with an aerodynamic diameter of 10 microns or less (PM₁₀).

All air quality parameters, except PM₁₀, will be collected as hourly averages using continuous gas analyzers. PM₁₀ concentrations will be collected as integrated 24-hour samples once every 6 days with high volume samplers following the federal sampling schedule. The site will include collocated PM₁₀ sampler operating on the same every-6th-day schedule as the primary sampler to assess the precision of the sampling methods. The collocated particulate samplers at the site will provide an assessment of the PM₁₀ precision for the Basin monitoring network.

3.2 Site selection

The basic objective of on-site PSD pre-construction monitoring program is to provide a database of quality assured data for use in dispersion modeling. The site was chosen to be representative of the proposed power plant location at a site that would provide site security and access. The site will provide baseline air quality data and representative meteorological data to use in dispersion modeling to characterize the dispersion of pollutant emissions from the stack and other potential facility sources. Because there are no topographical features in the region that are likely to significantly impact the meteorological conditions the meteorological data will be representative of all of the proposed sites for the power plant. Additionally, since the monitoring location is not near any industrial sites or urban areas, a common characteristic of all the proposed power plant locations, the air quality data will also be representative for any of the proposed locations.

3.3 Description of monitoring location

Figure 3-2 presents an area topographic map showing the proposed the ambient monitoring location. Table 3-1 provides the latitude, longitude, and Universal Transverse Mercator (UTM) coordinates of the Site, as well as the Site elevation. Views toward each cardinal direction from the Site are presented in Figures 3-3 through 3-6. The Site is proposed to be located in the foreground of each photograph. The station shelter would be located on a level gravel pad and fenced to prevent unauthorized access and protect the site from wildlife and cattle. An addendum will be submitted to SDDENR with photos of the sampling station as built including the views in the 8 cardinal directions, the sampling station and equipment, which are likely to be very similar to the depictions in the existing photographs.

Table 3-1 Locations of Basin ambient monitoring station (need update)

Data	Basin Monitoring Site
Latitude	45° 02' 37.28"
Longitude	99° 50' 11.88"
UTM North (m; NAD83)	4,988,123
UTM East (m; NAD83)	434,103
UTM Zone	14
Elevation (feet-mean sea level [msl])	2,037
AQS Site Number	46-107-0101

As can be seen from the pictures in the four cardinal directions, the additional pictures will show little variability.

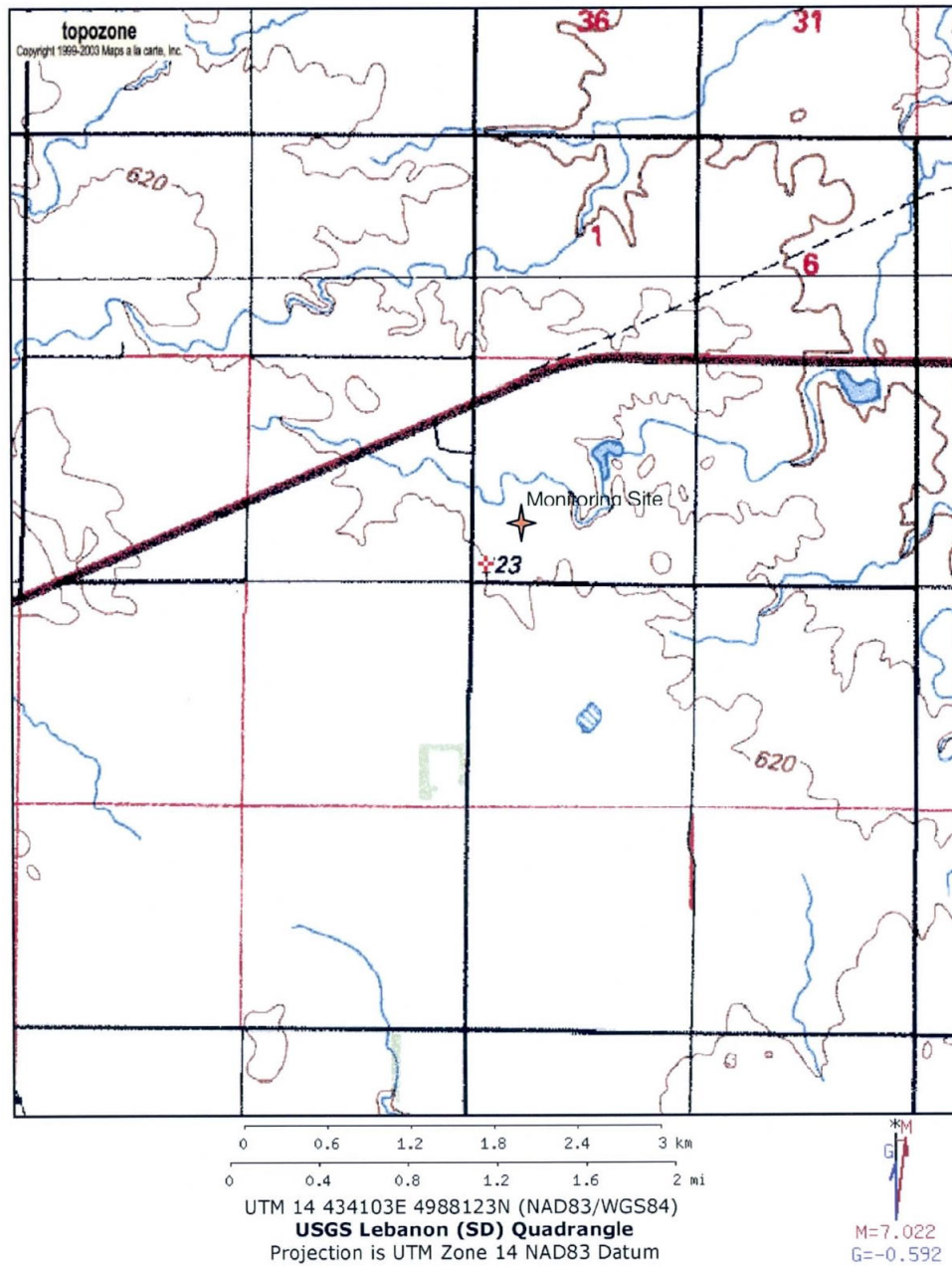


Figure 3-2 Topographic map of site location



Figure 3-3 Proposed Basin monitoring site looking north



Figure 3-4 Proposed Basin monitoring site looking east



Figure 3-5 Proposed Basin monitoring site looking south



Figure 3-6 Proposed Basin monitoring site looking west

4.0 Monitoring equipment description

This section summarizes the air quality and meteorological instrumentation used for the proposed BASIN monitoring program. This instrumentation has been selected to be compatible with, and provide data which satisfy the USEPA's Ambient Air Quality Surveillance (40 CFR 58). Additional guidance is provided by the USEPA's Ambient Monitoring Guidelines for PSD (USEPA 1987). The air quality instruments that are to be used satisfy either Reference or Equivalent methods as described in 40 CFR 53.

Table 4-1 provides a list of each parameter, sample frequency, and sampling method used in the proposed BASIN monitoring program. Except for high volume PM₁₀ samples, all data will be collected as continuous hourly averages. High volume PM₁₀ samples will be collected once every 6 days according to the USEPA established schedule, and reported as integrated 24-hour averages. Manufacturer's specifications for the proposed instrumentation are located in Appendix D.

4.1 Air quality instrumentation

4.1.1 Nitrogen oxides analyzer

Ambient levels of NO_x will be monitored continuously using Thermo Electron Corporation (Thermo) Model 42C NO_x analyzer. This instrument has been selected for use in the proposed BASIN study because it is ultra-sensitive, interference free, and provides long-term zero and span stability for continuous monitoring of NO, NO₂, and NO_x with a high degree of reliability.

The Thermo 42C detects NO in ambient air by reacting NO with O₃. The resulting chemiluminescent reaction is monitored through an optical filter by a photo-multiplier tube (PMT) which is located at the end of the reaction chamber. The optical filter limits the wavelength of light measured by the PMT, so that it corresponds to the wavelength of the chemiluminescent reaction between NO and O₃.

Total oxides of nitrogen will be measured by passing the sample gas through a catalytic converter which converts NO₂ quantitatively into NO which is subsequently measured by the detector. The microprocessor-controlled analyzer directs sample flow either through the catalytic converter (measuring NO_x) or by passing the sample directly into the detector (measuring NO). Signals from the PMT are conditioned and fed to the microprocessor where a sophisticated mathematical algorithm is utilized to calculate three independent outputs: NO, NO₂, and NO_x.

4.1.2 Ozone analyzer

Ambient O₃ concentrations will be measured using a Thermo 49C O₃ analyzer. The Thermo 49C uses an ultraviolet (UV) photometric ozone analyzer design. It incorporates a unique two-sample absorption cell and detector design for increased sensitivity and accuracy.

In principal, the UV photometer determines ozone concentrations by measuring the attenuation of UV light due to ozone in the absorption cell. The concentration of ozone is directly related to the magnitude of the attenuation. In the Thermo 49C, an internally generated reference sample passes into the absorption cell to establish a "zero" light intensity reading. A solenoid valve then switches, and an ambient sample is taken, thereby establishing a "sample" light intensity reading. The ratio of these two readings is a measure of the light absorbed by ozone and is directly related to the concentration of ozone in the sample.

Table 4-1 BASIN ambient monitoring program equipment and measurement methods

Parameter	Manufacturer/Model	Sample Frequency	Range	Method	EPA Method Number
NO _x , NO ₂ , NO (~4m)	Thermo Electron Corporation (Thermo) Model 42C	Continuous	0.001 to 0.500 ppm	Chemiluminescent single chamber	RFNA-1289-074
O ₃ (~4m)	Thermo Model 49C	Continuous	0.002 to 0.500 ppm	Ultraviolet absorption	EQOA-0880-047
SO ₂ (~4m)	Thermo Model 43C	Continuous	0.001 to 0.500 ppm	Pulsed fluorescent	EQSA-0486-060
PM ₁₀ (~4m)	Tisch TE-6070V Volumetric Flow Controlled PM ₁₀ monitor	Every 6 days	2 to 750 µg/m ³	10 µm size select inlet, high volume filter sample, gravimetric analysis	RFPS-0202-141
Multi-gas calibrator	Thermo Model 146C	NA	0 to 100 cc 0 to 10 lpm	Mass flow meters	
Ozone Transfer Standard	Thermo Model 49C TS	NA	0.001 to 0.500 ppm	Pulsed fluorescent	
Horizontal wind speed 10m, 50m, 100m	Climatronics Model F460	Continuous	0.1 to 100 mph	Cup Anemometer/Photo-chopper	
Horizontal wind direction 10m, 50m, 100m	Climatronics Model F460	Continuous	0° to 360°	Vane/Potentiometer	
Sigma-theta 10m, 50m, 100m	Campbell Scientific CR23X Datalogger	Continuous	0° to 100°	Digital computation	
Vertical Wind Speed 10m, 50m, 100m	Climatronics Model 102236-G0	Continuous	-12.5 to +12.5 mph	Propeller Anemometer	
Sigma w 10m, 50m, 100m	Campbell Scientific CR23X Datalogger	Continuous	0° to 100°	Digital computation	
Temperature 2m, 10m, 50m, 100m	Climatronics Model 100093	Continuous	-30°C to 50°C	Aspirated triple-element thermistor	
Temperature Difference (10m-2m, 50m-2m, 100m-2m, 100m-50m)	Climatronics Model 100093	Continuous	-5° to 10°	Aspirated triple-element thermistor	
Solar Radiation (~4m)	Kipp & Zonen Model CMP3	Continuous	0 to 2 langley/minute	Thermopile	
Precipitation (~4m)	Climatronics Model 100097-1-G0	Event, 1-hour Accumulation	0.01 in to Unlimited	Tipping Bucket	
Relative Humidity (2m)	Campbell Scientific, Model HMP 45C-L	Continuous	0 to 100 percent	Hygrometer	
Barometric Pressure (~4m)	Climatronics Model 102663-G0-10	Continuous	600 – 1,100 hPascals	Solid State Piezoresistors	
Data logger	Campbell Scientific CR23X	1/second	0-1 v	Digital computer	

ppm = parts per million
 µg/m³ = micrograms per cubic meter
 µm = micrometers
 cc = cubic centimeters
 lpm = liters per minute
 mph = miles per hour
 °C = degrees Celsius
 v = volts

With this design, a small (1 parts per billion [ppb]) change in O_3 concentration requires the photometer intensity to be stable to less than 2 parts per 105 in the typical 10-second reference/ambient sample cycle. To meet the stability criteria, the Thermo 49C employs two photometers and uses two separate absorption cells and detector systems. These two detector systems operate simultaneously, alternating reference and ambient samples. When one detector is sampling ambient air, the other is sampling reference air. By integrating the signals and averaging each calculated chamber concentration, fluctuations in UV lamp intensity can be factored out. The microcomputer in the Thermo 49C calculates the O_3 concentrations directly for each cell and outputs the average concentration in both a front panel digital display and an analog output.

4.1.3 Sulfur dioxide analyzer

Ambient levels of SO_2 will be monitored continuously by using a Thermo Model 43C SO_2 analyzer. Based on ENSR's experience, the Thermo 43C Pulsed Fluorescence SO_2 Analyzer provides unequalled ease of operations reliability, precision, and specificity. This analyzer does not use consumable gases or wet chemicals. The Thermo 43C operates on the principle of fluorescent radiation of SO_2 molecules. A reaction chamber is irradiated by UV light and the fluorescent radiation is detected by a sensitive PMT. Associated electronics amplify the output from the PMT. The output voltage is proportional to SO_2 concentrations.

4.1.4 Particulate samplers

A high-volume PM_{10} sampler draws a known volume of ambient air at a constant flow rate through a size-selective inlet and through a filter. Particles in the PM_{10} size range are then collected on the filter during the specified 24-hour sampling period. Each sample filter will be weighed before and after sampling to determine the net weight (mass) gain of the collected PM_{10} sample. The federal reference method for PM_{10} sampling is given in 40 CFR Part 50, Appendix J (USEPA 1987).

PM_{10} sampling will be performed using Tisch TE-6070V Volumetric Flow Controlled PM_{10} monitor samplers. The Hi-Vol unit consists of a motor assembly, critical flow device, removable sample filter holder, lapsed time meter, mechanical timer, aluminum housing, and 10 μm size selective inlets. The samplers will be mounted on a platform adjacent to the air quality instrument shelter.

4.1.5 Gas analyzer calibration systems

The air quality monitoring station at BASIN will be equipped with a Thermo Model 146C Multigas Calibration System. The TEI 146C is an air quality calibration system with mass flow controllers. The calibration system combines solenoid valves, power supplies, and other major components that have been used for air quality applications for several years with state-of-the-art control technology which will allow users to remotely conduct Level-1 precision checks and multi-point calibrations. The diluent air mass flow controller has a range of 10 standard liters per minute (SLPM) and the gas mass flow controller has a range of 100 cc/minute. The mass flow controllers assure a precise mixing ratio for accurate and precise calibration gas generation using the electronic closed-loop control. The CPU calculates both the required gas and diluent air flow rate and controls the corresponding mass flow controllers accordingly.

The principle of gas phase titration is based on the rapid gas phase reaction between NO and O_3 which produces stoichiometric quantities of NO_2 . Given that the NO concentration is known prior to this reaction, the resultant concentration of NO_2 can be determined. After the addition of O_3 , the observed decrease in NO concentration on the NO channel is equivalent to the concentration of NO_2 produced. The Thermo 146C is designed to satisfy complete reaction (less than 1 percent residual O_3) based on USEPA guidelines. NIST traceable USEPA protocol 2 bottled calibration gases will be used. UV photometer transfer standards for O_3 calibrations also will be employed.

4.2 Meteorological instruments

At the proposed Basin site, meteorological data will be collected from an instrumented 100-m tower. The specific instruments and equipment are described in more detail below.

4.2.1 Horizontal wind speed and direction

Horizontal wind speed and direction on the tower will be measured continuously at the proposed Basin site using Climatronics Model F460 wind systems (100075-G0-H0 for wind speed; 100076-G0-H0 for wind direction). Wind speed will be measured using an anemometer where the principle of operation is based on a light chopper that produces a frequency proportional to wind speed. The wind direction sensor will be a lightweight vane that senses position by a precision potentiometer. The wind sensors will be installed at 100 m, 50 m, and 10 m. The standard deviation (σ -theta) of the wind direction is computed by the data logger using the USEPA-preferred Yamartino method (USEPA 2000).

4.2.2 Temperature and temperature difference

Temperature at the proposed Basin site will be measured at three levels on the tower using a Climatronics Model 100093 temperature system. This motor aspirated system includes dual element thermistors mounted at 100 m, 50 m, 10 m and 2 m above ground level. Delta-T is calculated by the datalogger based on the difference in temperatures measured by identical sensors at each of the levels, 100-2 m, and 50-2 m. The datalogger resolves the temperature difference to better than 0.1°C.

This sensor configuration is designed to provide complete signal wire compensation and to eliminate any measurement errors resulting from resistance of the signal cable. The aspirator is mechanically ventilated with a fan to prevent conductive interference from precipitation and radiation from solar and terrestrial sources.

4.2.3 Vertical wind speed and standard deviation

Vertical wind speed on the tower will be measured continuously at the proposed Basin site using Climatronics Model 102236-G0 wind systems. Vertical wind speed will be measured using an anemometer where the principle of operation is based on a prop that rotates either clockwise or counter-clockwise, which corresponds to positive or negative voltages that are translated into upward and downward vertical wind speed. The wind sensors will be installed at 100 m, 50 m, and 10 m. The standard deviation (σ -w) of the wind direction is computed by the data logger following the guidelines in USEPA (2000).

4.2.4 Solar radiation

At the proposed Basin site, radiation measurements using a Kipp & Zonen model CMP3 pyranometer located at about the 2 m level. The sensor is designed for measurement of global (sun and sky) radiation. The detector is a differential thermopile made of plated copper on constantan junctions. Hot-junction receivers are covered with a stable black coating, cold junction receivers are whitened with non-hygroscopic barium sulfate. The sensor is temperature compensated using thermistor circuitry to within 1.5 percent of the range of -20°C to +40°C. The sensor is sensitive to wavelengths of 0.285 to 2.800 μ m.

4.2.5 Relative humidity

RH will be measured, at 2 m, using a Campbell Scientific model HMP 45C-L humidity sensor. The sensing element is a small hygroscopic thin film capacitor that modifies its value as a function of both the water vapor pressure and temperature of the environment. The sensor probe electronics automatically compensate for temperature effects on the probe. Sensor output signals are data logger compatible requiring no additional processing.

4.2.6 Barometric pressure

Barometric pressure will be measured using a Climatronics Model 102663-G0-10 pressure sensor. The pressure sensor is a piezoresistive device. The sensor is ideally suited to applications requiring accurate measurement of pressure. The sensor provides 0-1V DC over a 600 to 1,100 hPascals range.

4.2.7 Precipitation

A Climatronics Model 100097-1-G0 6-inch tipping bucket precipitation gauge will be used to measure rainfall. Precipitation is channeled to a triangular bucket that tips once for each 0.01 inch of water collected. When the bucket empties, it activates a switch that is monitored and recorded by the data acquisition system.

4.3 Tower and continuous gas analyzer data acquisition systems

The station will be equipped with redundant data collection systems to achieve maximum data retrieval. The primary data source will be hourly digital data collected by a Campbell Scientific CR3000 datalogger. This unit is equipped with a telephone modem or other telemetry modem and link to provide a near-real time interface to ENSR computers for network status checking and data backup. The datalogger, and will be equipped with a solid state data recording module, that will be changed out as needed to supplement or update the primary database.

4.4 Miscellaneous equipment

Support equipment for the proposed Basin monitoring site includes a Rohn 100-m tower (or equivalent). The site will have an 8-foot x 12-foot x 8-foot instrument shelter with exterior and interior lighting, heating, air conditioning, equipment rack, and table. The shelter will be skid-mounted and ground-anchored with cement anchors. Shelter internal temperature will be maintained within a control range of 20-30°C via a thermostat and the heating and cooling systems. For data validation purposes temperature will be measured and tracked by the data logger.

An inventory of consumable items will be necessary for the efficient operation of the meteorological systems and to ensure the specified data recovery rate. Sufficient supplies will be maintained at the stations to ensure continuous system operation. ENSR also has an in-house inventory of spare parts for all equipment items installed at the proposed Basin site. This inventory contains all common failure items as well as those costly parts that seldom fail. Thus, in the event of failure of an unusual part, two sources of supply are available. In addition, ENSR maintains complete spare instruments for most of the parameters measured in this program which can be temporarily substituted into the network should an instrument malfunction occur.

5.0 Station operational procedures

This section describes the routine procedures used in operating the proposed Basin ambient monitoring program. All procedures have been specifically designed to provide appropriate quality control and ensure that valid data recovery meets or exceeds the PSD requirements of 80 percent for air quality parameters (quarterly) and 90 percent for meteorological parameters (annually).

In this section, the various components of the station operational procedures will be individually described. These include:

- Equipment integration and testing;
- Station installation;
- Routine network operations; and
- Monitor calibrations.

The descriptions of network operations provided in this section are augmented by ENSR's SOPs and Technical Instruction (TECHINS) listed in **Table 5-1**. Activities relating to testing, installation, operation, and maintenance of the equipment used in this program will conform to the USEPA Ambient Monitoring Guidelines for PSD; and supplemented by ENSR SOPs, where applicable. Pertinent SOPs and TECHINS for the proposed Basin monitoring program are included in Appendix C.

5.1 Equipment integration and testing

ENSR will conduct considerable testing of the monitoring equipment during the pre-operation phases of the program. All project equipment tests will be performed according to ENSR SOPs, be fully documented and, where appropriate, traceable to authoritative standards.

Prior to systems integration and assembly, an operational check will be performed in the ENSR laboratory on each individual instrument. The operational check will be conducted according to a set of SOPs for calibration, accuracy, and stability. A quality control form specific to each instrument will be completed and verified for compliance with performance requirements. In the event an instrument or system fails the operational check, appropriate repairs will be made, or the instrument returned to the manufacturer for repair. The operational check for instruments repaired or replaced will be repeated.

After all equipment has been checked and accepted, the monitoring systems will be assembled, integrated, and tested. The design provides sufficient electrical surge protection, and will be optimized for convenience and ease of operation. The system will be fully assembled, integrated, and labeled in exactly the same configuration as anticipated in the field. The system will be activated for operational testing. These tests consisted of continuous analyzer checks using test atmospheres, meteorological system performance checks, and data collection system checks. Following the control checks, each system will be run under ambient conditions for several days to check system stability and verify compliance with operational specifications. Before shutdown at the end of the program, each sensor will be calibration checked and any suspected instrument problems will either be corrected or the unit will be replaced. Each component serial number and network assignment number will be logged along with testing results.

Table 5-1 Listing of SOPs and technical instructions used by ENSR in operating the proposed Basin ambient monitoring site

Number	Rev.	Date	Title
2400	2	3 rd Qtr. 2006	Traceability of Standards for Ambient Monitoring
2600	4	3 rd Qtr. 2006	Ambient Monitoring Field Calibration Control Plan
2630	3	2 nd Qtr. 1993	Routine Data Collection and Evaluation
2660	2	2 nd Qtr. 1993	Meteorological Sensor Siting and Calibration
2750	1	2002	Test Equipment Calibration/Repair
2900	1	4 th Qtr. 1993	Field Audit of Air Quality Monitoring Networks
2990	5	3 rd Qtr. 2006	Ambient Monitoring Data Validation
2991	1	2 nd Qtr. 1993	Continuous Air Measurement Data Reduction and Editing
4000	3	3 rd Qtr. 2004	Data Validation of Air Quality and Meteorological Data
2000-165	4	3 rd Qtr. 2006	Field Calibration: Wind Speed System
2000-166	3	3 rd Qtr. 2006	Field Calibration: Wind Direction System
2580-001	3	3 rd Qtr. 2006	Transfer Standard Flowmeter Calibration
2580-200	0	2 nd Qtr. 2006	Operation and Calibration of the API Model 700 Calibrator
2600-101	1	2 nd Qtr. 1993	Calibration Check or Audit Using a Thermo Model 49C Ozone Transfer Standard
2600-137	3	2 nd Qtr. 2006	Installation, Calibration of the Thermo Model 42C Oxides of Nitrogen Analyzer
2600-225	2	2 nd Qtr. 2006	Operation, Calibration, and Maintenance of the Thermo Model 43C SO ₂ Analyzer
2600-700	1	2 nd Qtr. 1994	Operation of the ENSR Portable Field Calibration System
2620-001	7	3 rd Qtr. 2006	High Volume Sampler Calibration for the Volumetrically Flow Controlled (VFC) Sampler
2620-002	5	3 rd Qtr. 2006	High Volume Sample Collection
2620-071	1	2 nd Qtr. 1993	High Volume Timer Field Calibration
2629-201	6	3 rd Qtr. 2006	Filter Processing Method for the Determination of Suspended PM ₁₀ SSI Particulate Values
2630-101	1	2 nd Qtr. 2006	Operation and Maintenance of Thermo 49C Ozone Analyzer
2660-210	1	4 th Qtr. 1994	Field Calibration Procedure: Temperature/Delta Temperature Monitoring System
2900-001	2	3 rd Qtr. 2006	Performance Audits of Air Quality Monitors
2901-001	1	3 rd Qtr. 2006	Technical Instruction: Documentation of Field Calibration of Continuous Air Quality Analyzers
2901-100	1	4 th Qtr. 1994	Quality Control Documentation Review Procedure
2990-001	2	3 rd Qtr. 2006	Technical Instruction: Calculation of Precision and Accuracy Statistics

5.2 Station installation and initial calibration

5.2.1 Site preparation and mobilizing equipment

All site preparation activities are the responsibility of Basin. These activities include gaining site access authorization, obtaining any necessary construction and special use permits, arranging for utilities, as applicable, and providing security fencing as required around the monitoring site.

At the completion of the systems integration and testing phase, the system will be partially disassembled and packaged prior to their shipment to the proposed Basin Site. All equipment in the racks and critical assemblies will be disassembled, packed in protective foam or appropriate packing boxes, and secured within the shelter. All spares and consumable supplies will be also packed and shipped in the shelter. Once the shelter is packed, the door will be secured.

Upon arrival, the monitoring shelter will be immediately off-loaded at the designated site. The shelter will be placed on supports, leveled, secured with anchors, and electrically grounded, and pre-prepared utility connections will be made. ENSR will contract with Tower Systems, Inc. to install the 100-m meteorological tower.

5.2.2 Site installation

The continuous gas analyzers will be installed in the environmentally controlled shelter and operated in the reference/equivalent configuration and settings as specified by the manufacturer. The samplers will be mounted on a platform adjacent to the air quality instrument shelter. Gas analyzer and sampler inlet heights will conform to the provisions of 40 CFR 58, Appendix E, Probe Siting Criteria for Ambient Air Quality Monitoring.

Meteorological tower instrumentation will be installed in accordance with USEPA siting criteria specified in USEPA (1987 and 2000).

Station installation activities will consist of the following:

- Tower Systems will install the 100-m tower;
- The particulate samplers will be mounted on a platform providing separation and height per specifications;
- The electrical power circuits will be connected and tested;
- The intake manifold and sampling cane will be installed at heights that conform to the provisions of 40 CFR 58, Appendix E, Probe Siting Criteria for Ambient Air Monitoring;
- The equipment racks will be integrated in exactly the same configuration as tested in the laboratory;
- The meteorological sensors will be mounted on the tower and signal cables connected; and
- The complete monitoring system will be powered-up and verified to be operational.

5.2.3 Initial calibration

Once installation activities are completed and all instrumentation activated, operationally tested, and stabilized in the field, complete ambient monitoring equipment calibrations will be conducted. The digital data acquisition system also verified by comparison with the digital voltmeter output. Calibration procedures for each instrument are outlined in Chapter 6.

5.2.4 Operational testing

After the startup calibration, the ENSR field operations supervisor and project air quality technician will remain on-site to verify the performance of the system under actual operating conditions. During this period, equipment stability will be the main concern. Any marginal equipment will be repaired or replaced. All activities will be documented using standard project forms. Examples of these forms are attached in Appendix A.

5.2.5 On-site technician training

Coincidental with the installation and operational testing activities, ENSR will provide additional training to the on-site technician regarding station operational procedures. Training will be focused primarily on routine station operations and inspection, maintenance, and quality assurance activities that will be conducted by the on-site technician. Suggestions and additional training will also be provided, as appropriate, throughout the entire term of the project by ENSR project technical personnel through routine telephone communications, during calibration visits, quality assurance performance audits, and other potential network service visits.

5.2.6 Site documentation

ENSR maintains the following support documentation at each site:

- Copies of manufacturer's operation and service manuals for each piece of monitoring, calibration, and test equipment;
- Copies of each SOP covering tasks to be performed in the operation of the monitoring system (SOPs will be complete with copies of each network document and examples of the proper recording of data on those documents); and
- A copy of this Monitoring Plan.

5.3 System operations and maintenance

5.3.1 Routine operations and maintenance

ENSR will operate the air quality and meteorological monitoring system according to USEPA PSD guidelines defined in 40 CFR 58 Appendix A, QA Requirements for SLAMS, SPM, and PSD Air Monitoring. ENSR supplements these guidelines with the Meteorological Monitoring Guidance for Regulatory Modeling Applications (USEPA 2000). Other guidance listed in Chapter 1.0 of the Plan and applicable requirements of SDDENR for monitoring programs and incorporates established SOPs and good scientific judgment in operation of the network.

Project field staff consists of the senior air quality technicians stationed at ENSR's Fort Collins, Colorado, office, and an independent auditor. The project manager has overall responsibility for operation and maintenance of the monitoring system.

ENSR's senior air quality technician will visit the site on a quarterly basis to calibrate the air quality systems and will perform calibrations on all the meteorological systems on a semi-annual basis. An auditor reporting through ENSR's QA Department will conduct performance audits of the air quality instruments each calendar quarter and will perform audits on all the meteorological systems on a semi-annual basis. Audit equipment including orifices, gases, and instruments will be different from the equipment, gases, and instruments used for calibration at the Basin site. Systems audits will be conducted by the independent auditor within about 60 days of startup and at least once a year. A summary and schedule for the field network activities are provided in **Table 5-2**.

Table 5-2 Scheduled field activities for the Basin ambient monitoring network

Field Operations Activities	Every Visit	Bi-Weekly	Monthly	Quarterly	Semi-Annually
Enter arrival time and date on the Station Log	X				
Change Hi-Vol PM ₁₀ filters and record pertinent data on filter jackets (every 6 days)	X				
Check displays on telephone modems	X				
Inspect the operational characteristics of each sensor	X				
Enter data on Site Checklist for each analyzer	X				
Enter the applicable data on the Status/Data Assessment sheets	X				
Record all pertinent observations and data in a narrative Station Log	X				
Check the inside temperature of the shelter and record temperature extremes	X				
Collect data sheets and station logs, and Hi-Vol filters and send them to ENSR Fort Collins by registered mail or FedEx		X			
Check meteorological data sensor cables for wear			X		
Assist with quarterly AQ calibrations				X	
Assist with quarterly AQ audits				X	
Assist or perform meteorological calibrations and calibrate test instruments					X
Systems and Performance audits – by independent QA auditor				X	X

The on-site technician will receive hands-on training at the site during and following installation, and will be given a site checklist to follow in the performance of duties. A list of Site technician duties is shown below (Table 5-3).

Table 5-3 Field operations checklist for the Basin ambient monitoring network

Field Operations Activities	Checked
Upon arrival, note arrival time and date on the Station Log.	
Change Hi-Vol PM ₁₀ filters and record pertinent data on filter jacket (every 6 days).	
Check display on telephone modem.	
Inspect the operational characteristics of each sensor/analyzer.	
Enter data in Site Checklist for each analyzer.	
Enter the applicable data on the Status/Data Assessment sheets.	
Record all pertinent observations and data in a narrative Station Log.	
Check the inside temperature of the shelter and record temperature extremes.	
Check condition of intake manifold filter cartridges. Change every 2 weeks.	
Collect data sheets, station logs, and Hi-Vol filters and send them to ENSR Fort Collins by registered mail or FedEx (monthly).	
Inspect tower and check meteorological data sensor cables for wear.	

The routine site visits are supplemented by daily computer interrogation of the monitoring station. The Campbell Scientific data logger gathers data from the met tower and will be equipped with a telephone modem for access by ENSR computers. This allows for daily station performance evaluation by ENSR operations personnel responsible for the monitoring program. It provides valuable information on a near-real time basis on the condition of each monitoring system.

Filter analysis will be conducted by ENSR. Filter processing including filter selection, filter preparation, filter tracking and gravimetric analysis procedures including all quality control procedures are detailed in SOP 2629-201.

5.3.2 Calibrations

In order to ensure collection of high quality data, frequent field calibration of monitoring instruments and recorders will be performed. These calibrations will be conducted by ENSR's Fort Collins-based air quality technician. Calibrations will be performed at least quarterly for air quality equipment and semi-annually for meteorological equipment. All calibration records will be examined by the project QA officer who has knowledge of the procedures but no direct involvement with the actual calibrations. Detailed calibration procedures for each instrument are provided in Chapter 6.

Instrument calibration checks will be required if any one of following criteria are met:

- At start-up and quarterly (air quality), or semi-annually (meteorology), thereafter;
- When any maintenance activity that may alter the response of any instrument is conducted;
- When the daily span of any of the continuous gas analyzers deviates by more than ± 10 percent (5 percent for O₃) from the designated span value;

- When audit results of the continuous gas analyzers show that the difference between the audit standard and the instrument response exceeds ± 10 percent (± 5 percent for O_3);
- When audit results of meteorological instrumentation exceeds the audit acceptance criteria;
- When a continuous gas analyzer has been shut-off for more than 2 days; and
- Prior to removal of an instrument from a station if it is still operational.

All calibrations of atmospheric monitoring equipment will conform to QA requirements as outlined in Ambient Monitoring Guidelines for PSD (USEPA 1987). Calibrations will be performed according to ENSR SOPs, which have been developed to meet the strict requirements of the USEPA regulatory guidelines for NIST traceability and documentation.

Documentation of all site visits will be provided through several forms. A station log will be maintained at the site detailing inspection, calibration, or repair activities. Records of measurements taken during calibrations will be recorded on forms designed specifically for the instrument under calibration. The station logs and calibration records will be printed on multi-copy forms for distribution. Copies of these are attached in Appendix A.

Test equipment used for calibrations will be maintained and calibrated on a regular basis. Records that provide traceability to the NIST of all equipment used for adjusting monitoring systems are maintained by ENSR. The following equipment will be used for calibrations of air quality instruments:

Calibration of the meteorological and data acquisition systems consists of pre- and post-maintenance dynamic calibrations in which the sensor (and/or system) is subjected to known conditions. These calibrations will occur at start-up and at least once every 6 months.

The following equipment will be used to conduct calibrations of meteorological instruments:

- Certified digital multimeter, Fluke 8060A or equivalent;
- Linearity test fixture F460;
- Map with reference points (exact directions);
- Compass;
- Variable speed stepper motor;
- Torque wheel (0.2 to 7 g-cm range);
- NIST traceable thermometers;
- Insulated temperature baths;
- Frequency counter (Fluke 1900A or equivalent); and
- Oscilloscope (Tektronics 335 or equivalent).

Details of the calibration of each analyzer or system are provided by the ENSR SOPs listed in Appendix C and are summarized in the following sections. Project accuracy goals for each parameter are presented in Table 5-4.

5.4 Preventive Maintenance

The preventive maintenance tasks and schedules recommended by the manufacturers of the continuous meteorological sensors will be followed. Wind sensor bearings will be replaced semi-annually.

In conjunction with the preventive maintenance schedule, a spare parts inventory has been developed. These parts will be available for immediate installation. When any one of the critical spare parts is used a replacement part will be ordered immediately or the failed component will be repaired or replaced to maintain the inventory count.

6.0 Quality assurance plan

6.1 Purpose and objectives

This QA plan describes the QA organization, responsibilities, procedures, documentation, audits, control limits, and data acceptance criteria for the proposed Basin ambient monitoring program. This monitoring program will be run in compliance with 40 CFR 58, Appendix A, QA Requirements for SLAMS, SPM, and PSD Air Monitoring. It is anticipated that this monitoring program will achieve and average data recovery rate in excess of 90 percent for meteorological parameters (annually) and 80 percent for air quality parameters (quarterly). The data accuracy goals for the parameters measured are chosen to be consistent with all PSD monitoring requirements. The accuracy goals for all measurements are listed in **Table 6-1**. If any audit or calibration checks reveal the instruments to be operating outside of the tolerance levels specified in **Table 6-1** than the data collected since the last valid check will be considered invalid unless correction is possible.

Table 6-1 Data Accuracy Goals Basin Ambient Monitoring Program

Parameter	Accuracy
Continuous Gas Analyzers	± 15 percent (upscale concentrations) and ± 0.015 ppm for zero checks (± 1.5 ppm for CO) for NO _x , SO ₂ and CO ± 7 percent (upscale concentrations) and ± 0.007 ppm for zero checks for O ₃
Particulate Samplers	± 10 percent of designated flow rate
Horizontal Wind Speed	± (0.2 m/sec + 5 percent of observed)
Horizontal Wind Direction	± 5.0 compass degrees and ± 3.0 degrees relative to sensor mount (linearity)
Vertical Wind Speed	± (0.2 m/sec + 5 percent of observed)
Temperature	± 0.5 °C
Delta-Temperature	± 0.1 °C
RH	± 10 percent
Barometric Pressure	± 0.09 in mercury
Precipitation	± 10 percent of observed or ± 0.5 millimeters (mm)
Solar Radiation	± 5 percent of observed

Note: Meteorological accuracy goals match those stated in USEPA 2000.

The precision goals for the continuous air quality measurements are the same as the accuracy goals. The precision goals for PM₁₀ as calculated from collocated samplers are 5 µg/m³ for PM₁₀ concentration less than 80 µg/m³ and 7 percent for PM₁₀ concentrations above 80 µg/m³.

All data will be reported in appropriate scientific or engineering units. The results of calibrations, audits, and precision checks will be kept on file at ENSR's Fort Collins office, reported in quarterly data summaries, and archived upon completion of the project for a minimum of 5 years.

Audit reports shall be issued promptly and addressed to the project manager. The audit report, including the original data sheets from the performance portion of the audit, will be archived at the ENSR Fort Collins office.

6.2 Organization and responsibilities

Figure 6-1 presents a project organization chart depicting key personnel and responsibilities.

The proposed Basin meteorological monitoring program will be administered under ENSR's Corporate QA Program, the policies of which are stated in the ENSR Corporate Statement of QA Policy and QA Manual for Air Measurements (see Appendix B). The corporate QA manager reports to the executive vice president of ENSR, assuring complete independence from line function. Additionally, each ENSR region has assigned a regional QA officer who reports to the corporate QA manager and directly supports QA programs in each regional office.

A QA department auditor or an independent third party (Figure 6-1) will perform the field audits under the direction of the project QA officer. Audit results will be presented in an audit report published by the corporate QA department, and follow-up to assure corrective action is taken, if necessary. A copy of the audit report and summary of any corrective action will be communicated to Basin Electric within 30 days of each project quarter end.

6.3 Standard operating procedures

All technical work will be controlled by formal written procedures in conformance with the provisions of the ENSR QA Manual for air measurements. A list of the SOPs applicable to the proposed Basin monitoring project is presented in Table 5-1. Copies of applicable ENSR SOPs are included in Appendix C.

6.4 Continuous air quality analyzers

6.4.1 Calibrations

In order to ensure collection of high quality data, frequent field calibration of monitoring instruments and recorders will be performed. These calibrations will be conducted by ENSR's Fort Collins based air quality technician. Calibrations will be performed at least quarterly for all air quality analyzers.

- Multi-point calibrations and spans will be performed using standards documented traceable to NIST. Calibration procedures are summarized in Section 5.3.2.
- Calibrations, zero checks, span checks, and precision checks will be done through the normal sampling trains (i.e., those scrubbers and filters normally employed during sampling).
- Automatic zero/span checks will be performed daily. No automatic adjustment will occur, but the information will be used to detect sudden malfunctions or changes in calibration that may warrant unscheduled maintenance visits. The span check concentration will be at 70 to 90 percent of instrument full-scale response.
- Level-I span, zero and precision checks will be performed automatically every week. Multi-point calibrations will be performed whenever the daily span exceeds 15 percent (7 percent for O₃) of expected.

Multi-point calibrations of the continuous gas analyzers consist of challenging each instrument with known concentrations at approximately 20, 40, and 90 percent of full scale. In addition to these points, a zero check will be performed on each analyzer. Gas phase titration (GPT) with ozone will be performed to assess NO₂-to-NO converter efficiency in the NO_x analyzer. Linearity over the range of each analyzer will be checked and adjustments made, as appropriate, to bring the analyzer response within the control limits.

The control limits for multi-point calibrations for the SO₂, NO_x, and CO analyzers is ± 15 percent for upscale concentrations, and ± 0.015 ppm for zero checks (± 1.5 ppm for CO). The control limits for multi-point calibrations for the O₃ analyzer is ± 7 percent for upscale concentrations, and ± 0.007 ppm for zero. For O₃, the action limit will be ± 5 percent in an attempt to achieve ± 7 percent.

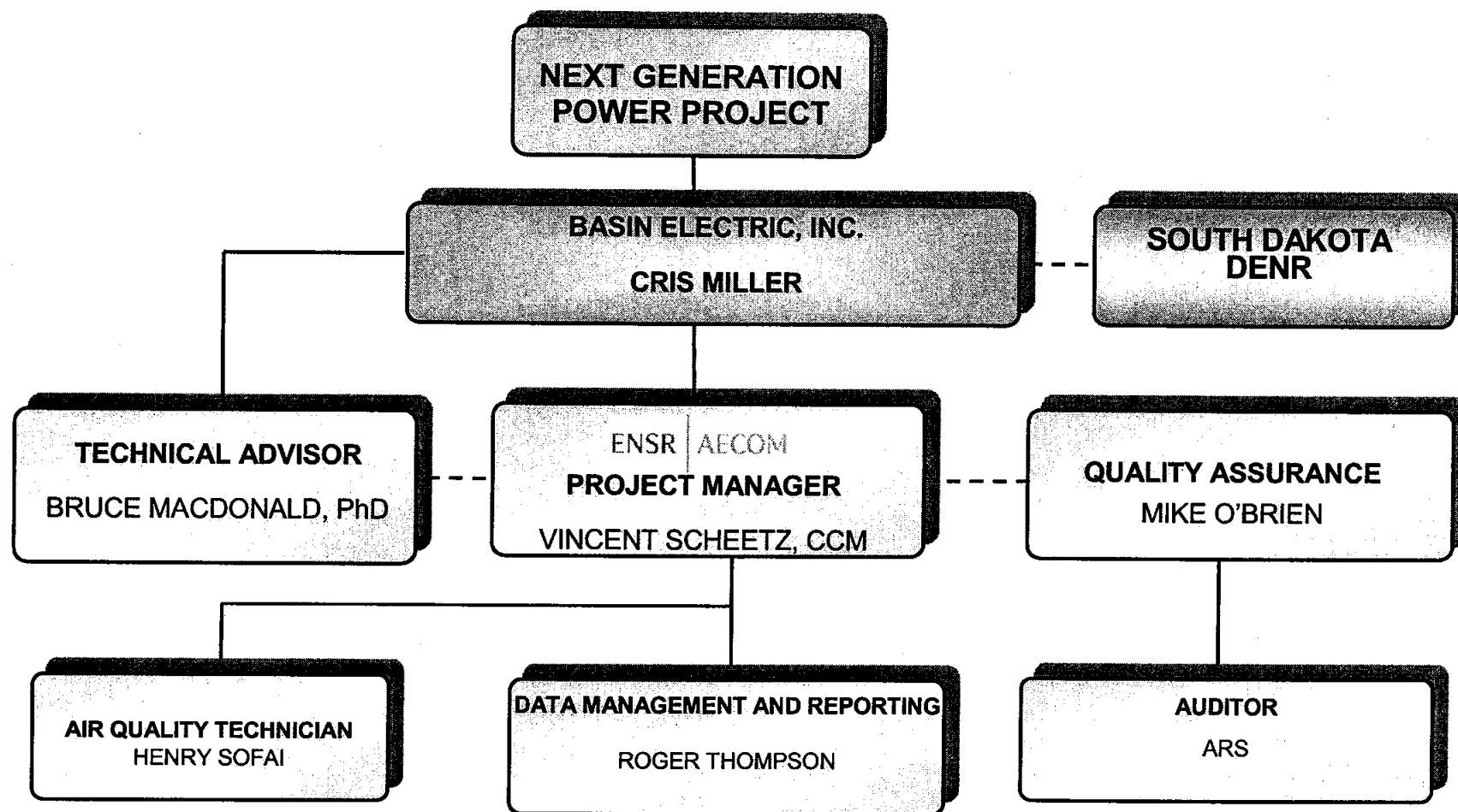


Figure 6-1 Organization chart for the Basin Electric ambient air quality monitoring program

6.4.2 Performance audits

Quality assurance performance audits will be conducted by independent persons assigned by the Corporate QA Department who have no responsibility for the operation of the network or by an independent third party contractor. Audit equipment will be different from that used in calibration of the analyzers; it may, however, be traceable to the same primary standards. Audits will occur within 60 days of start-up and quarterly thereafter.

Audits will be performed in conformance with 40 CFR 58 Appendix A, QA Requirements for SLAMS, SPM, and PSD Air Monitoring and ENSR TECHIN No. 2900-001. Audits will consist of three test atmospheres, and a zero check.

Audits will be conducted by introducing the test atmosphere to the analyzer through its normal ambient sampling system. These procedures are the same as those described by the section on instrument calibrations.

The percent difference between the actual concentration of the audit test gas and the concentration indicated by the analyzer will be used to assess the accuracy of the monitoring data. The action limit on performance audit results is 10 percent (5 percent for O₃). If the percent difference at any audit point exceeds this limit, a full multi-point calibration of the instrument will be performed. The control limit on performance audit results is 15 percent (7 percent for O₃) or 15 ppb (7 ppb for O₃) whichever is greater. If this limit is exceeded, affected data may be excluded from the database and will be investigated prior to invalidating any data. Accuracy data compiled from the audit results will be submitted as part of the quarterly report.

Audit challenge ranges and acceptance criteria for continuous (gaseous) analyzers are shown in Table 6-2.

Table 6-2 Gaseous Analyzers Audit Challenge Ranges and Acceptance Criteria

Parameter	Audit Concentration Ranges (ppm)						Acceptance Criteria
	Zero	Level 1	Level 2	Level 3	Level 4	Level 5	
O ₃	0	0.02-0.05	0.06-0.08	0.15-0.20	0.36-0.45	n/a	±7% or ±7 ppb for any point
SO ₂	0	0.0003-0.005	0.006-0.01	0.03-0.08	0.15-0.20	0.36-0.40	±15% or ±15 ppb for any point
NO/NO ₂ /NO _x ¹	0	0.003-0.005	0.03-0.08	0.15-0.20	0.35-0.45	n/a	±15% or ±15 ppb for any point
CO	0	0.50-1.00	1.50-4.00	5.0-15.0	15.0-20.0	36.0-45.0	±15% or ±1.5 ppm for any point

¹NO₂ audit errors due to inevitable minor NO-NO_x channel imbalance may be minimized by modifying the GPT technique to lower the NO concentrations remaining in NO₂ audit gas to levels closer to a minimum of 0.08 ppm remaining NO.

²Audit ranges provided in Table 6-1 may be changed to conform to future guidance from USEPA regarding implementation of 40 CFR 58 Appendix A. The lowest audit levels are being included for completeness but may not be reasonable for inclusion in standard PSD tolerance evaluations using standard approved PSD monitoring equipment.

6.4.3 Precision assessment

Precision data will be derived from the biweekly precision checks. Each week the analyzer will be challenged with a known concentration of gas. The normal sampling system including any filters will be used when performing these tests. The percent differences between known and observed concentrations provide

the information necessary to compute precision of the data. The exact procedure and equations for this calculation are given in 40 CFR 58, Appendix A, Section 4. Action limits for precision checks have been set at 10 percent (5 percent for O₃). Control limits have been set at 15 percent (7 percent for O₃). If this limit is exceeded, affected data may be excluded from the database.

The precision check is performed first, by challenging the instrument with a known concentration at 0.080 to 0.100 ppm and recording the response. The precision check is followed by a zero check. Finally, the Level-I span check is performed by challenging the instrument with a known concentration of 70 to 90 percent of full-scale response for NO_x, NO, O₃, and SO₂. For NO_x, SO₂, and CO, if the instrument response differs for the precision or span check from the known input by more than 10 percent a full multi-point calibration must be performed. For O₃, if the instrument response differs for the precision or span check from the known input by more than 5 percent a full multi-point calibration must be performed. For NO_x, SO₂, and CO, if the percent difference is between 5 and 10 percent, the instrument span control is adjusted to obtain a response that matches the input. Whenever the span is adjusted, the zero check is repeated and the zero control is readjusted if necessary.

Zero checks must be within 0.015 ppm (0.007 ppm for O₃) or the analyzer must be recalibrated.

Precision and zero/span checks will be performed prior to any manual calibrations, or any other adjustment to the analyzer. Precision checks are not affected by instrument replacement. If more than one analyzer is used in a given quarter to collect the same parameter, documentation will show the change of equipment, but the final precision statistics will reflect all the percent differences observed during the quarter.

Precision checks will be performed using the instrument calibration devices or the in-station gas dilution unit calibrator.

6.5 High volume samplers

6.5.1 Calibrations

Calibration of the particulate samplers will be done with NIST traceable calibration system using variable resistance orifices, to produce a series of different flow rates in the range of 30 to 60 actual cubic feet per minute. Actual flows derived from calibration curves shall be corrected using seasonal values for temperature and pressure or on-site temperature and pressure readings.

The particulate samplers shall be multi-point calibrated:

- Upon start-up;
- Upon shutdown;
- After maintenance, such as motor change;
- Upon exceedence of tolerance limits;
- At least once every per calendar quarter; and
- After an audit shows a ± 7 percent discrepancy.

6.5.2 Performance Audits

The flow rate of the high volume sampler will be audited quarterly by using an NIST-traceable orifice and manometer (with unity oil in sub-freezing weather) to measure the flow rate (true) through the sampler for comparison with the flow rate determined simultaneously with the site indicator and calibration curve (indicated). A full audit as described in sections 3.3.3 and 3.2.4 will be performed quarterly in place of the quarterly flow rate verifications required under 40 CFR 58 Appendix A section 3.3.2. As a full audit is a more

conservative test of the instrument performance this should be an acceptable way to show compliance with the accuracy standards. If the percent difference between true and indicated flow rates exceeds 7 percent, the sampler must be re-calibrated. Changes in flow rate calibration of more than 10 percent may invalidate all samples collected back to the last calibration or valid flow check, and the sampler must be re-calibrated. Audit results greater than 10 percent will warrant further investigation prior to invalidating samples. Audit methods and acceptance criteria for particulate samplers are shown in **Table 6-3**.

Table 6-3 Particulate samplers audit methods and acceptance criteria

Parameter	Audit Method	Acceptance Criteria
Particulate filter sampler	Audit orifice flow to actual sampler flow	±10 percent
Particulate filter sampler	Design criteria flow to actual sampler flow	±10 percent

6.5.3 Precision assessment

Precision statistics will be generated from the percent differences between the primary particulate samplers and the respective collocated samplers for PM₁₀ at the Basin site. The percent differences are then used to compute 95 percent confidence limits in accordance with 40 CFR Part 58, Appendix A.

6.5.4 Filter sample custody

ENSR's laboratory will provide a supply of pre-weighed filters to the site technician. Each filter will be enclosed in a pre-printed filter jacket containing spaces for all required sample information to be filled in by the field site technician. Exposed particulate samples will be sent first to ENSR's gravimetric laboratory for determination of particulate concentrations.

Each filter is folded in half and returned to its filter jacket (folder) and placed in a plastic bag. The site technician will place the filters and site logs into a plastic container and ship them to the ENSR Fort Collins laboratory and data center on a monthly basis. (SOP 2620-002). ENSR's laboratory is responsible for tracking incoming field samples. A laboratory logbook will be maintained and will contain, as a minimum, the following:

- Sample number
- Date received and date analysis completed; and
- Technician performing the analysis.

6.6 Tower meteorological sensors

6.6.1 Calibrations

Sensors will be aligned, tested, and calibrated at least once every 6 months using test equipment traceable to authoritative standards, and following ENSR SOPs, and manufacturer's manuals.

6.6.1.1 Horizontal and vertical wind sensors

Detailed calibration procedures for calibrating the horizontal wind speed and direction, and vertical wind speed systems are listed in ENSR SOPs 2000-165 and 2000-166.

Factory calibration of the horizontal and vertical wind speed sensors provide NIST traceability through wind tunnel testing. Field calibrations will be performed semi-annually by using a known revolution per minute

motor, which is coupled to the wind speed sensor. The sensor output will be checked using a frequency counter and compared against the original sensor calibration (i.e., mph versus frequency). The wind speed translator will then be calibrated for the proper output based on this frequency. The sensor will be examined for physical integrity and a bearing quality evaluation will be made using a torque wheel.

Semi-annual field calibrations of the horizontal wind direction sensors include verification of proper azimuth orientation, system linearity, and proper crossover. Verification of the azimuth entails using direction markers to sight in the orientation of the wind vane. To ensure that the wind direction system response is linear, the system's output will be checked in both clockwise and counter-clockwise directions. A sensor-bearing quality evaluation will also be made using a torque wheel.

6.6.1.2 Ambient temperature

The ambient temperature system will be calibrated semi-annually by submerging the probe into continuously stirred and thermally-insulated water baths (an anti-freeze bath and a warm water bath) which are monitored using NIST traceable thermometers. During these calibrations the temperature aspirators are also inspected to verify functionality. Calibration procedures for the temperature system are presented in ENSR SOP 2660-210.

6.6.1.3 Solar radiation

The solar radiation sensor will be sent to the manufacturer annually for certification. Semi-annual checks of the solar radiation sensor will also be conducted by colocated comparisons to a reference standard. Colocated sensor readings will be obtained for three 15-minute averaging periods, and the average percent difference will be compared to the acceptance criteria. The reference standard is traceable to the World Meteorological Organization.

6.6.1.4 Barometric pressure

The barometric pressure sensor will be sent to the manufacturer annually for certification. Semi-annual checks of the barometric sensor also will be conducted by comparison with a colocated NIST traceable portable barometer. Colocated sensor readings will be obtained for three 15-minute averaging periods, and the average percent difference will be compared to the acceptance criteria. The unit will be adjusted to match the reference standard if the unit is out of specific tolerances.

6.6.1.5 Relative humidity

The RH sensor will be calibrated by comparison with readings taken using a colocated relative humidity sensor. The colocated sensor is a laboratory certified relative humidity probe. Alternatively, psychrometric readings using certified wet and dry bulb thermometers in a common fan aspirated radiation shield are compared with the on-site relative humidity readings. Wet and dry bulb readings are then converted to relative humidity using psychrometric tables.

6.6.1.6 Precipitation

The tipping bucket precipitation gauge will be calibrated using a volumetric flask and pipette. Known amounts of liquid will be introduced to the gauge and the resulting volume compared to manufacturer's specifications.

6.6.1.7 Data collection system

The Campbell data logger will be calibrated quarterly against reference voltage standards and a certified digital multimeter.

6.6.2 Performance audits

Meteorological systems will have performance and systems audits within approximately 60 days of start-up, within 30 days of shutdown, and at 6-month intervals.

Meteorological measurement systems will be audited in strict accordance with ENSR SOPs and in conformance with the provisions of USEPA's Quality Assurance Handbook, Volume IV (USEPA 1995), which calls for physical challenging of each sensor. The auditor would utilize NIST-traceable test equipment for the meteorological performance audits.

Unless adverse weather conditions cause excessive delay, the auditor conducts the meteorological sensor challenges with the sensors remaining on the tower. The acceptance criteria for performance audits are provided in **Table 6-4**.

Table 6-4 Tower meteorological sensors audit ranges and acceptance criteria

Sensor	Parameter	Audit Challenge Ranges	Acceptance Criteria
Wind speed	Speed accuracy	Three RPM values	$\pm (0.2 \text{ m/s} + 5\% \text{ of observed})$
	Starting threshold	Starting torque	$\leq 0.2 \text{ g-cm (horizontal)}$ $\leq 2.0 \text{ g-cm (vertical)}$
Wind direction	Orientation accuracy	To and from two landmarks	$\pm 5^\circ$ in any direction
	Response threshold	Starting torque	$\leq 7.0 \text{ g-cm}$
Temperature and temperature difference	Accuracy and linearity	Three temperature baths: 0°C, near ambient, and near full scale	Temperature $\pm 0.5^\circ\text{C}$ Δ Temperature $\pm 0.1^\circ\text{C}$
Relative humidity	Accuracy	Collocated compared to ambient	Relative humidity $\pm 10\%$
Solar radiation	Accuracy	Three collocated readings	$\pm 5\%$ of observed
Precipitation	Accuracy	Compared to three known amounts of water	$\pm 10\%$ of observed
	Tip response	Manual tips	One contact closure per tip
Barometric pressure	Accuracy	Compared to ambient	± 3 millibars

6.6.2.1 Horizontal and vertical wind speed

The wind speed sensors will be tested at three shaft revolution speeds using a variable speed motor. The equivalent wind speed will be calculated corresponding to the manufacturer's specified values for shaft RPM versus wind speed, and compared to readings obtained from the on-site data logger. A bearing integrity check also will be performed.

6.6.2.2 Horizontal wind direction

For the audits of the wind direction sensors, two landmarks will be sighted. The wind vane will then be oriented toward and away from each of the landmarks, resulting in a total of four test points for the sensor. The two landmarks will be at angles separated by about 90 degrees, so that the four test points represent the entire azimuth. Wind direction system readings will be obtained from the data logger output. A bearing integrity check will also be performed.

6.6.2.3 Ambient temperature

Each temperature sensor will be immersed in three temperature baths with a NIST-traceable thermometer. The temperature tests will be performed at 0 degrees °C, ambient, and approximately 40°C. Readings of the bath temperatures will obtained with the NIST-traceable thermometer will be compared to the on-site data logger output. Temperature difference will be assessed by simultaneously immersing both sensors in each of the three baths and noting the measured temperature difference between sensors.

6.6.2.4 Solar radiation

Audit of the total solar radiation sensor will be challenged by comparison to a collocated reference standard. Collocated sensor readings will be obtained for three 15-minute averaging periods, and the average percent difference will be compared to the acceptance criteria. The reference standard is calibrated and traceable to the World Meteorological Organization.

6.6.2.5 Relative humidity

The RH sensor will be audited by comparison with readings taken using a collocated relative humidity sensor. The collocated sensor is a laboratory certified relative humidity probe. Alternatively, psychrometric readings using certified wet and dry bulb thermometers in a common fan aspirated radiation shield are compared with the on-site relative humidity readings. Wet and dry bulb readings are then converted to relative humidity using psychrometric tables.

6.6.2.6 Barometric pressure

The barometric pressure audit will consist of challenging the sensor with a certified, collocated instrument which has been recently checked against a standard barometer at the nearest National Weather Station station.

6.6.2.7 Precipitation

The accuracy of the precipitation gauge will be verified by challenging the 0.01 inch tipping bucket mechanism with a known volume of water. The rate of flow through the gauge will be monitored and will be slower than 25 mm/hour. The volume of water will be sufficient to cause a minimum of ten tips. The gauge orifice will be measured to determine the effective collecting area.

6.7 Station system audits

The purpose of the system audits is to provide independent review of the design and operating practices of the monitoring network.

Prior to conducting an audit, the auditor performs the following tasks:

- Review the QA Plan to become familiar with the system design, the purpose of the monitoring, and applicable operating procedures.
- Become familiar with the calibration equipment to be used in the field.
- Assure that all calibration equipment used for the audit has been verified within required time limits (see SOP 2600) and that all test equipment is in current calibration. (See SOP 2750, Test Equipment Calibration/Repair.)

During the on-site portion of the system audit, the QA auditor performs the following:

1. Verify that the site location and configuration match those given in the monitoring plan. Document any variances and note whether or not required approvals will be granted.
2. Verify that meteorological instruments are located at appropriate heights and distances from obstacles for the surrounding terrain (USEPA 1987 and 2000). If meteorological instruments are not properly sited, it should be determined whether there is documentation of an approved variance.
3. Inspect the shelter and surrounding area noting accessibility (road conditions), cleanliness, orderliness, shelter temperature control, and Occupation Safety and Health Administration safety standards pertaining to electrical connections, ladders, railings, and storage of any combustible and toxic gases.
4. Inventory all monitoring and recording equipment by manufacturer, model number, serial number, age (if available), and date of last calibration, where appropriate.
5. Verify that meteorological systems (digital or analog), meet minimum accuracy requirements as indicated by manufacturer and applicable USEPA or agency guideline specifications. Also, verify that each meteorological sensor meets the appropriate PSD specifications (see Ambient Monitoring Guidelines for PSD Section 5.2 and references therein).
6. Verify that all instruments are in current calibration. There should be documentary evidence showing that all calibrations are traceable to NIST or equivalent standards.
7. Review the written procedures of the site. Written procedures should be available on site for the technician's reference and should be adequate to ensure data validity. The technician should be evaluated as to his or her knowledge of correct procedures.
8. Review site documentation (logs, maintenance schedules, calibration documents, calibration stickers) to ensure that correct procedures are being followed.

6.8 Quality assurance documentation

The most important criterion for data validity is the documentation of each instrument's calibration to show traceability and timeliness. Data within control limits and meeting these requirements will be deemed valid.

The following presents an overview of documentation maintained with respect to the proposed Basin meteorological monitoring program.

6.8.1 Standard operating procedures

Written procedures exist that control the operation and calibration of each monitoring station. These procedures contain sufficient detail to eliminate the possibility of producing different results through misinterpretation, or a change of personnel.

6.8.2 Site logs

A station log will be kept at each site for recording site activities: visitors, unusual occurrences, calibrations, maintenance activities, malfunctions, and repairs. Each entry will be dated and signed, and each instrument identified by make, model, and serial number.

6.8.3 Calibrations and audits

Calibrations will be documented on standard forms and copies kept both at the site and at the data processing facility. Quality assurance audits will be documented in written reports. Copies of all calibration forms and audit reports will be included in each quarterly report.

7.0 Data validation, data processing, and reporting

7.1 Data validation and editing

This section defines the criteria and process for determining the validity of ambient air quality and meteorological data. These criteria will be applicable to all data collected and apply to all ENSR personnel performing these tasks. Data validation criteria are based on the USEPA Quality Assurance Handbook, Volumes I, II, and IV (USEPA 1994a,b, 1998, and 1995, respectively). Data validation procedures are described in ENSR SOP 4000.

The on-site and project air quality technicians are responsible for the first phase of data validation, wherein first-hand knowledge of instrument performance to prescribed tolerances is required to determine data quality. Documentation of the operator's data assessment is critical to validation. The technicians use the criteria described in Sections 7.1.1 and 7.1.2 to the extent that such information is available. For the proposed Basin site, responsibility for instrument performance evaluation will be shared by ENSR operations personnel through daily interrogation and operational assessment of the data collectors via computer telecommunications link and routine site visits. Documentation of the daily near real-time assessment will be part of the operation control information base and will also assist in the data validation task.

The project air quality data analyst and project QA officer are responsible for the second phase of data validation, wherein they selectively review the field data documentation, calibration data, and operator data assessments to ensure adherence to tolerances and procedures and to provide the review essential to quality control. All such activities are documented on standard forms and logs.

Final data validation activities are the responsibility of the program manager and the project QA officer. These parties have the ultimate responsibility for performing the project data validation activities and sign-off on finalized data reports.

Continuous parameters are spot checked against for accuracy determination. Gross error checks, based on expected instrument range values, will be performed.

For data to be considered valid, it should: 1) be accurate and precise within prescribed limits; 2) represent factual conditions; 3) be obtained from a calibrated, well-functioning instrument; 4) be from air sampled without interference or obstruction; and 5) be thoroughly documented as to traceability to recognized primary standards.

The minimum standards for acceptance of the ambient monitoring data are detailed below. Data that satisfy the criteria below will be considered valid. Those that do not satisfy these criteria will be considered invalid.

If any of the information necessary to make the above evaluations is not available, the data shall be considered suspect until further review, comparison, investigation, etc., shows it to be valid or invalid. If no conclusive evidence to the contrary can be found, the data will be considered to be valid. Audit results alone will not be the basis for declaring data invalid.

7.1.1 Minimum standards for the acceptance of meteorological data

In order for data from the tower meteorological sensors and systems to be considered valid, the following conditions must be satisfied:

- The meteorological systems must be operated and calibrated according to applicable ENSR SOPs.
- Calibrations or tests that document systems performance within the specified tolerances must bracket the data. These tolerances are the same as the project accuracy goals.
- There must be sufficient documentary evidence in the form of calibration/test data and field logs or status/data assessment sheets to support the validity of the data.
- Minimum documentation needed is all calibration/test data and evidence of at least two on-site inspections per month.

7.1.2 Minimum standards for the acceptance of continuous air quality data

In order for data from continuous air quality analyzers to be considered acceptable, the following conditions must be satisfied:

- Instruments shall be calibrated to the requirements of appropriate SOPs, which describe frequency, protocol, and tolerances.
- The data must be bracketed by multi-point calibrations, or by at least one multi-point and one zero/span check, which document the system performance. These checks must show that the analyzer was operating within the project accuracy goals.
- The in-station calibrator used to provide the calibration data will have been verified on a quarterly basis.
- The data must be completely identified with respect to time, site, parameter, scale, and units.
- Documentary evidence of the traceability of the data must exist in sufficient detail to enable reconstruction of instrument history. The minimum requirements are the QC approved calibration data sheets or equivalent, and the field log and station checklists.
- Required minimum documentation is all calibration/test data and evidence of at least two on-site inspections per month.

The accuracy tolerance for validating the data collected since the last satisfactory quality control check is a difference, or drift from true, of 15 percent of the concentration or 15 ppb (1.5 ppm for carbon monoxide), whichever is greater. This tolerance limit applies to zero, precision and span checks and to the average percent difference of all the points of an "as found" multi-point calibration. Failure to meet the ± 15 percent tolerance limit requires invalidation of the data back to the last calibration, zero, precision, span check or audit which shows the analyzer operating within the tolerance limit.

7.1.3 Minimum standards for the acceptance of particulate data

In order for data from the particulate samplers to be considered acceptable, the following conditions must be satisfied:

- The particulate samplers must be operated and calibrated according to applicable SOPs.
- The data must be bracketed by calibrations or tests which document that the instruments are sampling at the correct flow rate specified by the manufacturer.
- There must be sufficient documentary evidence in the form of calibration/test data and field logs or station checklists to support the validity of the data.
- Sampler precision must be verified by regular comparison with the collocated sampler data.
- The filter media must not be torn or have pinholes in the sample area.

- Any pieces missing from the non sample area of the filter must be available for post weighing.
- There must be no indication of leakage around the sealing gasket.
- The total sample time must be 1440 minutes \pm 60 minutes.
- The sample beginning and ending times must be within 30 minutes of midnight (Local Time).
- The sampler flow rate must not vary by more than 10 percent from the correct design flow rate.

The accuracy tolerance for validating the data collected since the last satisfactory quality control check is a difference, or drift from true, of 15 percent (7 percent for O_3) of the concentration or 15 ppb (7 ppb for O_3 and 1.5 ppm for carbon monoxide), whichever is greater. This tolerance limit applies to zero, precision and span checks and to the average percent difference of all the points of an "as found" multi-point calibration. Failure to meet the above percent tolerance limits requires invalidation of the data back to the last calibration, zero, precision, span check or audit which shows the analyzer operating within the tolerance limit.

7.2 Particulate sample analyses

7.2.1 Gravimetric analysis

Gravimetric filter analyses will be conducted by ENSR at its Fort Collins, Colorado laboratory. Filter processing steps and quality assurance procedures are detailed in SOP 2629-201. PM_{10} filters will be equilibrated for a minimum of 24 hours before gravimetric analysis. The balance used for filter weighing will be calibrated annually by a service contractor and whenever the balance is moved or fails daily calibration check (tolerance \pm 0.5 milligram [mg]). As a quality control measure, at least five filters each day of weighing of both clean and exposed filters will be re-weighed by a second laboratory technician. The tolerance for clean filters is \pm 2.8 mg and for exposed filters \pm 5.0 mg. Upon completion of the laboratory analysis the filter samples will be archived for a minimum of three years.

7.3 Data processing

The primary data recording medium for the meteorological and continuous air quality data will be the Campbell near real time data acquisition systems installed at the stations. The Campbell unit calculates averages, formats, and temporarily stores the data in internal battery backed up memory. The primary database will be generated from the data retrieved during daily telephone interrogation of the data logger. As part of the daily systems check, the data from the station will be stored into a data file on PCs and the ENSR network drives located at ENSR's Fort Collins, Colorado, office. Redundant data collection sources will also be used in the event that any data are missing due to system or phone line failure. The backup and supplemental data system consists of a removable data cartridge in the data logger. Data stored on this cartridge will be included into the primary database as needed.

The following subsections provide an overview of how data handling, data reduction, data correction, and data checking will be conducted a part of the data processing activities for the proposed Basin monitoring project.

7.3.1 Data handling

Field data from the Basin monitoring site will be sent by the site technician to the ENSR Fort Collins data center approximately once a month. Data shipments include field data, field operations logs, calibration documentation, and status assessment sheets.

Upon receipt, all project data will be logged. A complete data inventory catalog will be updated for each shipment specifying "on" and "off" times for all filter samples, data logger output, data cartridges, and analog records.

Initial inspection of all data shipments will be performed to verify completeness and continuity with respect to the previous shipment (comparison of "off" and "on" times). Daily data logger printouts will be inspected to identify timing problems or field sensor malfunctions. The digital data or cartridges will be translated and stored in ENSR's computer facilities immediately upon receipt from the field to verify data integrity.

Printouts of the data logger will be archived for further processing. Documentation of field operations will be reviewed by the field operations supervisor for completeness, network performance, and compliance with network operating procedures. All documentation will be filed for reference.

7.3.2 Data reduction

The primary source of continuous data for the monitoring project database is data retrieved during daily telephone computer interrogation checks and subsequently translated into ENSR's computer database. The database is complete with error diagnostic systems, editing capability, and display subsystems which allow the user ready access and cost-effectiveness control of the database.

The primary data provided by the particulate monitors are the exposed filter media. Other data needed to calculate the ambient particulate concentration include sampler flow charts and sampler timer data. These data are used to determine the mass of particulate collected via gravimetric analysis of the filter media, and to determine the volume of air sampled, which is calculated using the sampler calibration relationship, total sample time, and average flow rate. Once the mass of particulate and the volume of air sampled are known, the concentration of particulate matter corrected to standard conditions can be calculated.

7.3.3 Validation and editing

Project data will be evaluated and validated prior to use in report generation and analyses. Evaluation and validation will be performed according to PSD QA requirements and ENSR SOPs (see Section 7.1).

Data evaluation tasks include:

- Review of field logs, maintenance and calibration reports, data review records, and automatic zero, precision and span checks;
- Review of error diagnostic summaries; and
- Reasonability checks, verified by network comparisons and comparisons with appropriate weather data from the stations in the region.

After periods of invalid or missing data have been identified, backup data from removable data cartridges, or printer records, will be reduced, verified, and entered into the database. If backup data are also invalid, missing data codes will be inserted.

Actual editing of the database will be performed using ENSR's air quality database management system and all deletions or modifications to the original database will be thoroughly documented in a logbook and on the listings to ensure traceability of project data. All edits will be independently verified by a second person. A backup copy of the original, unedited digital data will be maintained along with copies of analog data that are not edited.

Each monthly file of the validated project data will be the final database for subsequent analyses and report generation. These project data files will be permanently archived on backup disks or magnetic tape and maintained in duplicate for protection. In addition, field operations documentation is filed along with original data forms for future reference.

7.3.4 Data corrections

Under rare circumstances, data may have a known quantifiable bias and may be corrected if the tolerances listed in MMGRMA guidance documents are not exceeded (i.e, 15 percent or 15 ppb, 1.5 ppm for CO). They are corrected only if all of the following conditions are met:

- The bias must have a single identifiable cause;
- The bias must have a clearly defined beginning and ending time;
- The accuracy tolerances for continuous air quality data are not exceeded;
- The data in question must meet the data validation criteria of Section 7.1; and
- The data must be greater than the minimum detection limit of the instrument (air quality data).

7.3.5 Data capture, precision, and accuracy

For continuous air quality and meteorological instruments, data capture is defined in the following manner:

$$\text{Data Capture} = \frac{\text{Number of valid hourly observations}}{\text{Number of possible hours}} \times 100$$

Equations used to calculate data precision and accuracy are summarized in ENSR SOP 2990-001.

7.4 Data reporting

Quarterly data reports will be prepared by ENSR and submitted to Basin Electric for submission to SDDENR prior to 60 days after each sampling quarter. Contents of the quarterly data reports include:

- A brief project description;
- A network performance summary with data recovery statistics and a discussion of significant events;
- Tabular listing of all hourly and 24-hour data with daily and monthly summaries;
- Digital copy of validated data and QC data contained in the quarterly report;
- Statistical and graphical data analyses consistent with those required in 40 CFR 58 appendix A ;
- Results of the quality assurance audits; and
- Data processing information.

The quarterly report is intended to serve as an independent data reference guide. It will be a bound report and will include a brief introduction and an appendix section containing relevant formulae. The tabular listings will be in the format shown in **Figure 7-1** and will present hourly minimums, maximums, and averages for all continuously monitored air quality and meteorological parameters.

A detailed annual report will be submitted to Basin Electric by ENSR within 60 days following the 12-month program. This report will be submitted under separate cover from the fourth quarterly report. This report will be similar in format to the quarterly data reports but summarizes the data for the entire 12-month period.

March, 2007

8.0 References

Code of Federal Regulations Title 40, Chapter I, Subchapter C, Part 58, Ambient Air Quality Surveillance.

U.S. Environmental Protection Agency (USEPA). 1987. Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD). EPA-450/4-87-007 USEPA Office of Air Quality Planning and Standards (OAQPS) Triangle Park (RTP), NC 27711.

_____. 1994a. Quality Assurance Handbook for Air Pollution Measurements, Volume I, A Field Guide to Environmental Quality Assurance. EPA-600/R-94/038a USEPA Office of Research and Development (ORD) Washington DC 20460, (1994).

_____. 1994b. Quality Assurance Handbook for Air Pollution Measurements, Volume II, Ambient Air Specific Methods (Interim Edition). EPA-600/R-94/038b, ORD Washington DC 20460, (1994).

_____. 1995. Quality Assurance Handbook for Air Pollution Measurements, Volume IV, Meteorological Measurements. EPA-600/R-94-038d, ORD Washington DC 20460, (1995).

_____. 1998. Quality Assurance Handbook for Air Pollution Measurements, Volume II, Part 1. EPA-454/R-98/004 OAQPS, RTP, NC 27711, (1998).

_____. 2000. Meteorological Monitoring Guidelines for Regulatory Modeling Applications. OAQPS, RTP, NC. EPA-454/R-99-005.

Yamartino, R. J. 1984. A Comparison of Several "Single-Pass" Estimators of the Standard Deviation of Wind.

Appendix A

Standard ENSR Project Forms

FIELD STATION LOG

LOCATION _____
 NETWORK _____
 SITE NO. _____
 PROJ. NO. _____

DATE	TIME	COMMENTS	INITIALS	EMP. NO.

WHITE COPY - DATA ● YELLOW COPY - DISTRICT OFFICE ● PINK COPY - FIELD STATION/SHELTER

FLOW METER CALIBRATION BY WET TEST METER

Date: _____

Technician _____

Facility: _____

Calibration Gas _____

Test Flow Meter:

Mfg _____

Model: _____

Type _____

Mfg S/N _____

ERT S/N _____

Reference Instrument:

Mfg _____

Model _____

Mfg S/N _____

ERT S/N _____

Range _____

Test Flow Meter to be Used With the Following Instrument:

Mfg

Model

Mfg S/N _____

ERT S/N _____

Ref. Thermometer #

Linear Regression Data:

b-

m = _____

 $r^2 =$ _____[illegible]

LITHIUM CHLORIDE DEWPOINT CALIBRATION DATA SHEET

SITE: _____ DATE: _____ BY: _____
 LEVEL: _____ RANGE _____ °F to _____ °F
 Wet Bulb _____ °F Dry Bulb _____ °F
 Calculated Dewpoint _____ °F
 Circuit Card O/P _____ V = _____ °F
 Recorder _____ °F Digital Data _____ °F

		CC O/P		Recorder		Digital Data	
Decade Box A	Decade Box B	Initial	Final	Initial	Final	Initial	Final

Specifications see Section 4.D

Circuit Card

	Initial	Final
Zero	_____	_____
Span	_____	_____

Dewcell Retreated _____ Stabilized _____
 Wet Bulb _____ °F Dry Bulb _____ °F
 Calculated Dewpoint _____ °F
 Circuit Card Output _____ V = _____ °F
 Recorder _____ °F Digital Data _____ °F

TEST EQUIPMENT

Psychrometer Mfg _____	Model _____	S/N _____	Recal Due _____
Decade Box Mfg _____	Model _____	S/N _____	Recal Due _____
DMM Mfg _____	Model _____	S/N _____	Recal Due _____
Voltage Source Mfg _____	Model _____	S/N _____	Recal Due _____

DATE _____ SITE _____ PROJECT _____

TIPPING BUCKET TYPE

Rain Gauge

Heading Information:

Initial/Final

Rain Gauge Serial No. _____; Mft./M.N. _____

Translator Serial No. _____; Mft./M.N. _____

System Checks

1. Zero/Span Switch Test:
(+ .001 volts)

Translator Zero _____ V(PCB); _____ cm (recorder)
(0.000V)

Translator Span _____ V(PCB); _____ cm (recorder)
(0.999V)

2. Functional Checks

	PCB Output =	Equiv. C.M. of rain	Recorder Indication	C.D.A.S. Indication
@ 0 Tips	_____	= _____	_____	_____
@ 99 Tips	_____	= _____	_____	_____

Reset to zero? _____

3. Volume Checks

_____ cc for 10 bucket tips (first test)
_____ cc for 10 bucket tips (second test)
_____ cc for 10 bucket tips (third test)
_____ cc for 10 bucket tips (ave. of 3 above tests)

4. Heater Operational? _____

Test Equipment	Instrument	Manufacturer	Model #	Serial #	Cal. Due

Comments:



WIND SPEED CALIBRATION

Network: _____ Site: _____ Level: _____

Sensor Manufacturer: _____ Model #: _____

Range: _____ to _____ mph; _____ to _____ volts

Technicians: _____ Date: _____

NOTE: Final serial numbers same as initial unless noted.

Sensor SN: _____

INITIAL SYSTEM CHECKS

Motor Speed (RPM)	Counter Indication (Hz)	Waveform		Translator SN:		Recorder SN: (MPH)	DAS (MPH)
		OK?	Amplitude	Volts	MPH		

Bearing Test:	Cups Condition:	Replaced?
---------------	-----------------	-----------

CIRCUIT CARD	Initial			Final		
	Voltage	Recorder	DAS	Voltage	Recorder	DAS
ZERO						
SPAN						

Test Oscillator Frequency (if applicable): _____

POWER SUPPLY	Initial Voltage	Final Voltage	AC Ripple
(+)			
(-)			

Sensor SN: _____

FINAL SYSTEM CHECKS (Tolerance of final system error = $\pm 1\%$ of full scale)

Motor Speed (RPM)	Counter Indication (Hz)	Waveform		Translator SN:		Recorder SN: (MPH)	DAS (MPH)
		OK?	Amplitude	Volts	MPH		

Bearing Test:		
---------------	--	--

TEST EQUIPMENT

Instrument	Manufacturer	Model	Serial Number	Recal. Due Date

Signature: _____ Q.C. Review: _____

Network: _____ Site: _____ Level: _____
 Sensor Manufacturer: _____ Model #: _____
 Range: _____ to _____ Degrees ± _____ to _____ Volts
 Technicians: _____ Date: _____

LANDMARK #1 _____ ANGLE _____ LANDMARK #2 _____ ANGLE _____

		Dual Pot Sensor (V)	Translator		Rec (°)	DAS	
			Volts	Deg			
Initial System Checks	To Landmark #1						
	From #1						
	To Landmark #2						
	From #2						
	Other						
	Circuit Card	Initial		Final			
		Voltage	Recorder	DAS	Voltage	Recorder	DAS
		Zero					
		Span					
		540° (if applicable)					

		Initial			Final°		
		Sensor (Volts)	Translator		Rec. (Deg)	Sensor (Volts)	Translator
		Volts	Deg		Volts	Deg	
Sensor Checks	Serial Number						
	CCW 2 Revs. to 10°						
	CW to 90°						
	CW to 180°						
	CW to 270° (align millmarks)						
	CW to 350°						
	CW 2 Revs. to 170°						
	CCW to 90°						
	CCW to 0°						
	CCW to 270° (align millmarks)						
CCW to 190°							
All Sensors	Max. Torque	_____ gm-cm			_____ gm-cm		
	Vane Condition	Replaced? _____			Replaced? _____		
	Pot. Switching	OK _____			OK _____		

		Dual Pot Sensor (V)	Translator		Rec (°)	DAS
			Volts	Deg		
Final System Checks*	To Landmark #1					
	From #1					
	To Landmark #2					
	From #2					
	Other					
Test Equipment	Instrument	Manufacturer		Model	Serial Number	Recal. Due Date

*To be completed if any repairs, adjustments or replacements are made.

NOTE: Final serial numbers same as initial unless noted.

Daily Log Sheet
Field Operations Activities

Site Location: NPS

Date:

mo day yr

Name: _____

1. Upon arrival, note arrival time, date, shelter min/max and current temperatures on temperature form. ☐
2. Inspect strip chart recordings and compare to digital information (using "U" command on terminal). Note any discrepancies on station log. ☐
3. Inspect daily span/zero results from previous nights calibration; record any deviations greater than 5 percent differential error. ☐
 - a. If deviation is 5 percent to 10 percent, initiate calibration sequence ("A" command on terminal), allow sufficient time for readings to stabilize, then adjust span or zero on affected instrument. ☐
 - b. If deviation is greater than 10 percent, contact ENSR's Anchorage office for technician visit. ☐
4. Perform precision checks on two week interval, using data acquired from most recent nightly span/zero calibration forms supplied. (If differential error exceeds 5 percent, see No. 3 above. ☐
5. Check flow rates (positive indication on TECO 43 and TECO 14 B/E rotameters), regulated and tank pressures on calibration tanks, internal temperatures on TECO 43 and 14 B/E for normal operation, and condition of desiccant cartridges. Replace desiccant if necessary. ☐
6. Record any pertinent weather observations on station log. ☐
7. Collect shelter temperature forms, field station logs, ENSR daily log sheet, hardcopy records, and data cartridges and mail to ENSR once each week, on Monday. ☐
8. Change HI-Vol PM-10 filters and record pertinent data on filter jacket every sixth day. ☐
9. Check condition of intake manifold filter cartridges. Change every two weeks as needed. ☐
10. Collect particulate filters and analog strip charts and mail to ENSR Anchorage office every 2 weeks. ☐

**Daily Log Sheet
Field Operations Activities**

Site Location:

Airstrip

Date:

 mo day yr

Name:

1. Inspect operation of Acoustic Radar system and remove snow and other debris from antenna dish.
2. Inspect operation of heater in precipitation measuring system (tipping bucket) and ensure free operation of bucket mechanism.
3. Annotate all strip charts with time, date, and initials, ensuring that time indicated on chart is in agreement with time indicated on Odessa datalogger.
4. Perform pH analysis of rainwater (or snow) for amounts greater than .10 inch in last 24 hours.
5. Check display on phone modem.
 - a. Ensure that power is on, by observing that the LEDs labeled "MR" (modem ready) and "TR" (terminal ready) are illuminated.
(Note that other LEDs may also be illuminated.)
 - b. Ensure that the 25 pin connector and cable from the Odessa datalogger is attached to the receptacle at the rear of the modem.
 - c. Ensure that the telephone cable and connector (RJ-11) is attached to the proper ("Wall" or "Line") receptacle at rear of modem.
6. Record any pertinent data and weather conditions on station log.
7. Collect all strip charts, acoustic radar chart, and pH log forms and forward to ENSR Anchorage every 2 weeks, by mail on Monday.
8. Collect all station log forms, daily log forms, shelter temperature log forms, and data cartridges and forward to ENSR Anchorage every week by mail.
9. Log current, minimum, and maximum shelter temps each day on station temperature form.
10. Inspect the operational characteristics of each sensor.
11. Determine the normalcy of the data acquired via strip charts and hardcopy printout since last visit.



WIND DIRECTION SYSTEM CALIBRATION

Network: _____ Site: _____ Level: _____

Sensor Manufacturer: _____ Model #: _____

Range: _____ to _____ Degrees = _____ to _____ Volts

Technicians: _____ Date: _____

LANDMARK #1 _____ ANGLE _____ LANDMARK #2 _____ ANGLE _____

	Dual Pot Sensor (V)	Translator		Rec (°)	DAS		
		Volts	Deg				
Initial System Checks	To Landmark #1						
	From #1						
	To Landmark #2						
	From #2						
	Other						
	Circuit Card	Initial			Final		
		Voltage	Recorder	DAS	Voltage	Recorder	DAS
	Zero						
	Span						
	540° (if applicable)						

	Sensor (Volts)	Initial Translator		Rec. (Deg)	Sensor (Volts)	Final* Translator		Rec. (Deg)
		Volts	Deg			Volts	Deg	
Sensor Checks	Dual Pot Only	Serial Number						
		CCW 2 Revs. to 10°						
		CW to 90°						
		CW to 180°						
		CW to 270° (align millmarks)						
		CW to 350°						
		CW 2 Revs. to 170°						
		CCW to 90°						
		CCW to 0°						
		CCW to 270° (align millmarks)						
CCW to 180°								
All Sensors	Max. Torque Vane Condition Pot. Switching	_____ gm-cm Replaced? _____			_____ gm-cm Replaced? _____			
		OK _____			OK _____			

	Dual Pot Sensor (V)	Translator		Rec (°)	DAS
		Volts	Deg		
Final System Checks*	To Landmark #1				
	From #1				
	To Landmark #2				
	From #2				
	Other				

Test Equipment	Instrument	Manufacturer	Model	Serial Number	Recal. Due Date

*To be completed if any repairs, adjustments or replacements are made.

NOTE: Final serial numbers same as initial unless noted.

Signature: _____ Q.C. Review: _____



DVM: Mfg and Model _____		SN _____	
Init: Zero Pot _____ Span Pot _____ Final: Zero Pot _____ Span Pot _____	Cylinder NO ₂	Converter Efficiency $\% \text{ C.E.} = \left[\frac{\text{NO}_x - \text{NO}_{\text{rem}} - \text{NO}_2 \text{ resid.}}{\text{NO}_{\text{orig}} - \text{NO}_{\text{rem}}} \right] \times 100 = \text{_____} \% (\geq 96\%)$	

In-Station Calibrator S/N

Avg. Δ% =

In-Station Calibrator Verification:

$$\Delta\% = \left[\frac{O - D}{D} \right] \times 100$$

(± 10%)

Signature: _____

Q.C. Review _____

Accepted ☐ Rejected ☐

Page 1 of 2

ENSR

GAS DILUTION/PERMEATION TUBE

Network _____ Site _____ Instrument Type _____ S/N _____ Date _____
 Calibrator: Type _____ S/N _____ Last Cal Date _____ Gas. Cyl. No. _____ Perm. Tube No. _____
 DVM: Mfg and Model _____ S/N _____ Last Cal Date _____

Init: Zero Pot _____ Span Pot _____	Perm. Temp. _____	Gas Cylinder Con. = _____ ppm
Final: Zero Pot _____ Span Pot _____	Des. = _____ °C, Obs. = _____ °C	Perm. Rate = _____ µg/min. at _____ °C

Flow Setting		Flow (cc/min.)		Input PPM _D (D)*	Unadjusted Readings (Obs)			Adjusted Readings (Obs)		Adjusted Readings (Obs)		Final Δ% (≤ 10%)
Dil. or Total (for Perm.)	Gas	Dil. or Total (for Perm.)	Gas		V _O (10-10V)	PPM _O (O)*	% Δ	V	PPM _O (O)*	V	PPM _O (O)*	

In-Station Calibrator S/N _____

In-Station Calibrator Verification:

Avg. Δ% = _____

Concentration (PPM)	Reference Calibrator			In-Station Calibrator			Δ% (± 10%)
	Flow Setting	Analyzer Response		Flow Setting	Analyzer Response		
		Volts	PPM (D)*		Volts	PPM (O)*	

$$\Delta\% = \left[\frac{O - D}{D} \right] \times 100$$

Signature: _____

Q.C. Review _____

Accepted ☐ Rejected ☐

Appendix B

ENSR's Corporate Statement of Quality Assurance Policy

Corporate Statement of Quality Policy and Organization

PHILOSOPHY AND POLICY

ENSR's quality policy is based on a definition of quality as conformance to requirements; and further, on the premise that the requirements are governed by client objectives as well as corporate policies and standard operating procedures.

ENSR is committed to the philosophy that productivity, profitability and client satisfaction result from quality achievement, and that optimum quality is best achieved through preventive rather than curative measures. Quality performance requires consensus between ENSR and its client with regard to the requirements of each project and design of project strategies based on those requirements. Therefore, ENSR's quality program is a cyclical process based on these three steps:

- 1) Development of project plans, representing agreement between ENSR and its client, that define project-specific requirements and the organization and procedures established to meet those requirements;
- 2) Quality Assessment through a program of project reviews, senior review, client feedback, audits, and quality control activities to ensure that each project is meeting its requirements;
- 3) Periodic re-evaluation and updating of project plans and procedures to ensure compatibility with changing project requirements and conditions, and to improve Quality whenever possible.

ENSR's policy is that the primary responsibility for improving quality in operation, production, data collection, processing and analysis, documentation, and report writing remains with the personnel performing the work. They shall perform their work in accordance with client requirements, project plans, standards of their profession, accepted quality practices, and applicable regulations. In the absence of specific guidelines, they will follow best scientific or technical judgement.

ENSR's quality program shall be based upon the applicable guidelines of the International Organization for Standardization (ISO), the American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), and the Environmental Protection Agency (EPA).

QUALITY PROGRAM ORGANIZATION

The President of ENSR Consulting and Engineering is responsible for fulfilling ENSR Consulting and Engineering's Corporate commitment to assure its clients of quality products and services. The President is aided by a Director of Quality Programs.

The Regional Vice Presidents and Client Service Center (CSC) Managers are responsible for the overall preparation and implementation of quality programs for the disciplines and service lines within their organizations, and for conducting periodic project reviews to assess project performance and achievement of client requirements.

Resource and Project Managers are responsible for preparation and day-to-day implementation of quality procedures applicable to their work.

The Regional Vice Presidents, CSC Managers and the Resource/Project Managers may appoint Quality Program Coordinators to help them fulfill their quality responsibilities.

The responsibilities of the Director of Quality Programs are to:

- 1) provide overall direction to and coordination of ENSR Quality Programs;
- 2) render advice and comment to both Corporate and operational management required to maintain and effect the Corporate Quality Policy and Programs;
- 3) maintain and distribute quality program documentation such as Quality Policy Statements, Quality Program Manuals, and non-project-specific Standard Operating Procedures;

- 4) assist and guide the efforts of those assigned quality program responsibilities on projects and for specific technical disciplines or service lines;
- 5) solicit, summarize, and report quality assessments provided by ENSR clients;
- 6) conduct or supervise periodic reviews of project-specific and discipline-specific Quality Programs;
- 7) advise line and project managers and Quality Program assignees of deficiencies in Quality Programs or performance thereto.

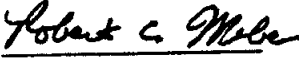
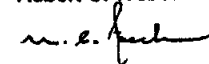
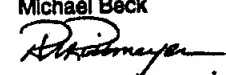

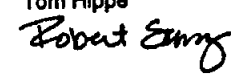
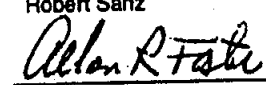
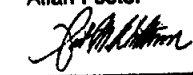
The responsibilities of the project managers (or their designees), for their particular projects, are to:

- 1) understand the client's requirements and ensure that the project team understands them;
- 2) generate and distribute project plans, manuals and/or standard procedures to define the project requirements and the procedures by which they will be achieved, and to establish project-specific quality criteria;
- 3) conduct project reviews and inspections to monitor performance and correct conditions that might interfere with achievement of project requirements;
- 4) review and update project plans as necessary to adjust to changing project requirements;
- 5) maintain hard-copy and electronic project records to ensure that all project plans, work products, and supporting documentation are retrievable and accessible by ENSR Management.

The responsibilities of resource managers (or their designees), for the resources they manage, are to:

- 1) indoctrinate personnel in the ENSR Quality Policies and Procedures;
- 2) conduct performance appraisals annually and include assessment of each person's attentiveness to Quality and compliance with project plans and procedures as well as ENSR Quality Policies and Procedures;
- 3) continually review service line strategy and delivery systems to ensure that they are adjusting effectively to changing client requirements.

ACCEPTANCE SIGNATURES

SIGNATURE	TITLE	DATE
 Robert C. Weber	President	8/27/99
 Michael Beck	Senior Vice President, Eastern Region	9/3/99
 Robert Rittmeyer	Senior Vice President, Central Region	6/28/99
 Tom Hippe	Vice President, Southern Region	6/28/99
 Robert Sanz	Vice President, Western Region	8/28/99
 Allan Foster	Vice President, Northwestern Region	8/27/99
 Scott M. Whittemore	Director, Quality Programs	9/3/99

Appendix C

Standard Operating Procedures

SOP NUMBER: 2400

Traceability of Standards for Ambient Monitoring

Date: 4th Qtr., 2006

Revision Number: 3

Author: Vincent Scheetz

Discipline: Air Measurements

1.0 PURPOSE AND APPLICABILITY

- 1.1 This Standard Operating Procedure (SOP) presents the standard methods of establishing traceability for calibrations of field sampling, measurement and monitoring instrumentation to National Institute of Standards and Technology (NIST) or other recognized standards. It applies to calibrations throughout ENSR in all of its ambient air quality and air emissions measurements programs.
- 1.2 Traceability is defined as the documentation that provides a historical record of the relationship of a parameter such as gas concentrations, volume, or temperature to a recognized authoritative standard, as measured by an approved method.

2.0 RESPONSIBILITIES

- 2.1 It is the responsibility of the individual performing the calibration and/or making the field measurements to do so in accordance with the project-specific Quality Assurance Plan (QAPP), relevant ENSR Standard Operating Procedures, and instrument manufacturers' documentation.
- 2.2 It is also the responsibility of the practitioner to document the calibration.
- 2.3 It is the responsibility of the project manager or designee to ensure that all necessary equipment is available and properly certified.
- 2.4 It is the responsibility of the project manager or designee to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 REQUIRED MATERIALS

Materials specific to the standards at hand are defined in the relevant ENSR monitoring or QA plan, and/or in the manufacturer's documentation. Examples of fundamental calibration standards are listed below.

- Bubble Flow Meter (Hastings HBM-1 or equivalent) (gas volume, flow rate)
- Sealed Piston

- Spirometer (Collins or equivalent) (gas volume, flow rate)
- Wet Test Meter (gas volume, flow rate)
- Mass Flow Meter (flow rate)
- Ozone Primary Standard (V.V. Photometer) (ozone concentration)
- NIST-traceable Thermometer (in applicable ranges) (temperature)
- NIST-traceable variable voltage supply (voltage)

4.0 METHOD

4.1 Gas Cylinders

- 4.1.1** All gas cylinders used for calibrations or span checks of air monitors should be purchased traceable to NIST by an appropriate accepted procedure. For continuous ambient and emission monitoring programs, the certification should be in accordance with Protocol G1 or G2 as specified in "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards", EPA-600/R93/224, September 1993.
- 4.1.2** If enough gas remains in the cylinder following the expiration of the certification, the cylinder should be shipped back to the manufacturer for recertification.
- 4.1.3** The manufacturer's tag shall remain attached to the cylinder. The information contained on the tag includes manufacturer, cylinder serial number, the protocol used for assay, identification of the Standard Reference Material (SRM) or NTIS Traceable Reference Material (NTRM) against which the concentration has been certified, tank pressure at certification, cylinder concentration, certification date and expiration date (see Table 1).
- 4.1.4** When the cylinder is received, the gas analysis report which accompanies the cylinder (or follows shortly thereafter by mail) should be retained in the project files. This report includes the same information as the cylinder tag, along with the actual data generated during the current analyses and any previous analyses.
- 4.1.5** Large gas cylinders (30 - 200 cubic feet) are to be used only when the tank pressure is >200 psi. Cylinders should be returned to the manufacturer for recertification if they contain greater than 750 psi. Similar considerations apply to smaller cylinders, and one detailed in the ENSR monitoring or QA plan and/or in the manufacturer's documentation.

4.2 Ozone Generators and Ozone Analyzer Calibration

- 4.2.1 Ozone concentrations are elevation-dependent and must be corrected for changes in elevation from the calibration location, if different from the monitoring site, by either 1) internal monitoring of bench temperature and pressure and corresponding adjustment of concentrations within the analyzer or, for analyzers without the ability to perform these internal adjustments, 2) manual temperature and pressure calculation and corresponding adjustments of ozone concentration as follows:

$$\text{Corrected } O_3 \text{ conc} = (\text{uncorrected } O_3 \text{ conc}) (P_{ca}/P_{site}) (T_{site}/T_{ca})$$

- 4.2.2 Each ENSR laboratory performing ozone verification will maintain or have access to a reference ozone standard. The unit will be set up and maintained as a primary standard according to the method detailed in 40 CFR Part 50 Appendix D, and ENSR SOP 2405.
- 4.2.3 Ozone generators used as a transfer standard for calibration or audit will be qualified, certified and recertified by direct comparison of the primary and reference photometers two days each quarter following the procedures detailed in EPA Technical Assistance Document EPA-600/4-79-056 entitled Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone.
- 4.2.4 Ozone generators which are part of Gas Phase Titration Calibrators must be certified as above if they are to be used to calibrate ozone analyzers.
- 4.2.5 An instation O_3 calibrator such as an internal generator (TECO 49, Dasibi 1003) or the Monitor Labs 8500 may be used as a span tracking device only and not for calibration of analyzers.

4.3 Flow Standards

All flow meters, flow controllers, dry gas meters, orifices, and rotameters that are used for calibrations or calibration checks shall be calibrated on a quarterly basis, unless project requirements call for more frequent calibrations. Meter boxes such as those used in emissions testing should be calibrated according to the method indicated in paragraph 5.3.1 of 40 CFR 60 Appendix A Method 5. Type S pitot tubes used for determining stack velocity in source testing should be calibrated according to the procedure outlined in Section 4 of 40 CFR 60 Appendix A Method 4.

- 4.3.1 Flow measurement devices shall be calibrated using one or any combination of the following primary or transfer standards:

- Sealed piston flow meter (volume)
- Bubble meter (volume)
- Spirometer (volume)
- Wet test meter (volume)
- Mass flow meter calibrated to any of the above.

Single-point flow standards (e.g., critical orifice) require calibration at the specific flowrate for which they are to be used as a standard, and are not valid at any other flowrate. Standards that are to serve over a range of flowrates must undergo multipoint calibration.

Multi-point flow calibrations will be performed using at least 3 calibration points. If the calibration is a straight line, 3 points may be adequate. Non-linear calibrations must employ as many points as necessary to obtain a smooth curve. The calibration data should encompass the range over which the flow device will be used. ENSR SOP 2580-001 Flowmeter Calibration may be used as a guide.

4.3.2 Spirometers and wet test meters will be recertified at least annually.

4.3.3 Personal sampling pumps and other flow-regulated sampling devices should be calibrated using bubble meters, calibrated orifices (see Section 4.8.1), or other similar devices before and after each use.

4.4 Time

Stop watches used for calibration should be checked at least semi-annually against the time signals emitted by WWV (shortwave radio broadcasts of NIST time signals).

4.5 Temperature

4.5.1 Thermometers, thermocouples, and other temperature measuring devices will be calibrated traceable to NIST by direct comparison with either an NIST thermometer, or a transfer standard such as electronic transducer thermometer or mercury in glass thermometer.

4.5.2 The precision of the reference standard must be at least twice that of the unit under test (UUT).

4.5.3 Mercury thermometers retain their original calibration unless the mercury separates. This condition requires a new calibration.

4.6 Pressure

Anaeroid barometers, or equivalent, are calibrated annually by the manufacturer.

4.7 Electronic Test Equipment

- 4.7.1** Digital voltmeters and all other electronic test equipment should be calibrated annually by comparison to an NIST-traceable variable voltage supply.
- 4.7.2** The vendor should submit, with each calibration, full traceability documentation including standards and methods used, and "as found" and "as left" readings. Vendor documentation should be filed in the project file.

4.8 Hi-Volume Calibrators

- 4.8.1** Orifices will be calibrated against a positive displacement meter no less than annually, and whenever nicks or dents at the orifice are visible. Copies of orifice calibration documents will be kept with the orifice, and originals will be filed in the project file.
- 4.8.2** Magnehelic gauges are considered part of a HI-VOL sampling system and do not have a stand-alone calibration. They are, however, calibrated by the manufacturer and guaranteed to be accurate to $\pm 2\%$ of full scale. They are not interchangeable.

4.9 Portable Gas Dilution Calibrators

- 4.9.1** Portable gas dilution calibrators shall be calibrated once each quarter in accordance with ENSR SOP 2580-001. In addition, the calibrator must have at least a one-point dynamic check performed for one pollutant test atmosphere prior to field use. The purpose of this check is to verify proper system operation.
- 4.9.2** Analyzer responses to inputs from the laboratory standard system and the test portable calibrator should agree within $\pm 3\%$.
- 4.9.3** If the responses do not agree, the reason for the discrepancy must be identified and rectified before the calibrator may be released for field use.

5.0 PORTABLE DEVICES

- 5.1** Portable air measurement devices such as handheld Photoionization Detectors (PIDs) or Flame Ionization Detectors (FIDs) and field gas chromatographs should be calibrated in the field prior to use, and periodically during use, employing calibration standards appropriate for the gases or vapors to be detected.

- 5.2** Field Calibration may be accomplished using appropriate gaseous standards in compressed gas cylinders. Standards may also be prepared by injecting neat solutions into evacuated Tedlar bags and filling the bags with a known volume of analyte-free air.
- 5.3** Portable particulate monitors may be checked for baseline through the installation of a particulate filter on the sample inlet. Calibration may be checked against an internal optical or electronic span device. Dynamic calibration of these sensors must be accomplished by the vendor or in a controlled environment (wind tunnel).

6.0 QUALITY CONTROL

Completed calibration data sheets are subject to senior review in accordance with ENSR's senior review policy. Calculations, standard conditions, correction factors, project identification, and other data will be reviewed for accuracy, completeness and conformance to ENSR SOP and the project-specific QAPP.

7.0 DOCUMENTATION

Complete calibration traceability records shall be retained in the project file.

8.0 REFERENCES

- 40 CFR 58, Appendix A, Quality Assurance Requirements for Prevention of Significant Deterioration.
- 40 CFR Part 60, Appendix A, Test Methods.
- 40 CFR Part 50, Appendix D.
- Quality Assurance Handbook for Air Pollution Measurement Systems; (all volumes).
- EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards, EPA-600/R93/224, September 1993.
- EPA Technical Assistance Document EPA-600/4-79-056 entitled Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone.

TABLE 1
NBS STANDARD REFERENCE MATERIALS (SRM)

Permeation Tubes		
SRM	Type	Nominal Perm. Rate ($\mu\text{g}/\text{m}^3$) at 25°C
1625	Sulfur Dioxide (10 cm)	2.8
1626	Sulfur Dioxide (5 cm)	1.4
1627	Sulfur Dioxide (2 cm)	0.56
1629	Nitrogen Dioxide -	(0.5 – 1.5)

Cylinder Gases			
SRM	Type	Volume	Nominal Value
1683	Nitric Oxide in N ₂	870 l.	50 ppm
1684	Nitric Oxide in N ₂	870 l.	100 ppm
1685	Nitric Oxide in N ₂	870 l.	250 ppm
2613	Carbon Monoxide in Air	870 l.	18 ppm
2614	Carbon Monoxide in Air	870 l.	42 ppm
1659	Methane in Air	870 l.	CH ₄ , 9.5 ppm
1666	Propane in Air	870 l.	C ₃ H ₈ , 9.5 ppm

SOP NUMBER: 2600

Ambient Monitoring Field Calibration Control Plan

Date: 3rd Qtr. 2006
Revision Number: 4
Author: Vincent Scheetz
Discipline: Air Measurements

1.0 PURPOSE AND APPLICABILITY

- This Standard Operating Procedure (SOP) describes the overall calibration control strategy to be utilized in ENSR ambient air pollutant measurement programs.
- The appropriate project-specific ENSR SOPs should be referred to for detailed instructions on the activities defined in this document.
- The purpose of this procedure is to ensure that the output of the field measurement process conforms to accurate standards and is traceable to NIST Standard Reference Material (SRM) or equivalent.

2.0 RESPONSIBILITIES

2.1 The field technician shall:

- be aware of and report to his supervisor circumstances that require calibration (see Section 4.6) and
- perform field calibrations and calibration checks in accordance with this and any referenced ENSR SOPs and the Quality Assurance Project Plan (QAPP).

2.2 The project manager (or designee) shall:

- ensure the availability of proper calibration equipment and the prompt calibration of all analyzers requiring calibration;
- review in a timely manner all calibration data including transfer standards, to detect any circumstances, actions, or lack of actions that are at variance with this SOP and supporting ENSR SOPs, or that may have resulted in an unacceptable calibration; and to accept or reject the data based upon such findings; and
- ensure that rejected calibrations are redone promptly, and forward accepted calibration documentation to the appropriate personnel.

3.0 REQUIRED MATERIALS

- Appropriate calibration data sheets
- Appropriate calibration transfer standards
- Calculator and/or computer

Refer to the project-specific ENSR SOPs for required materials.

4.0 METHOD

4.1 Calibrators

4.1.1 Span checks may be performed using an in-station or reference calibrator.

4.1.2 Calibration, Level 1 span checks and precision checks may be performed only with an NIST-traceable reference calibrator that has been calibrated within the past three months and a single component gas cylinder which has had its concentration certified within the previous 18 months.

4.1.3 Audits are to be performed with an independent audit calibrator, that is a calibrator which has not been used in the routine operation of the network.

4.1.4 Prior to use of a reference calibrator verify that the calibrator:

- is drawing dilution air from outside the shelter,
- is sufficiently warmed up,
- is properly certified with complete documentation
- preventive maintenance (leak check) has been performed.

4.2 Manual zero/span checks with in-station calibrator

4.2.1 "DOWN" the appropriate channels of the data acquisition system (DAS) to exclude the check from the valid ambient data base. Be sure to "UP" the channels to resume collection following the procedure.

4.2.2 Manually activate zero/span mode and observe stable analyzer responses to zero and span gas.

4.2.3 Compare observations with recent automatic zero/span results to verify consistency. Should the analyzer response to either the zero or span challenge be outside the tolerance limits ($\pm 1\%$ full scale and $\pm 5\%$ respectively), verify the input concentration and use the reference calibrator to confirm the results. If the responses of the analyzer to the reference calibrator zero and span challenges are the same, then the analyzer must be adjusted. If the analyzer is subsequently found to be operating within prescribed system tolerances using the reference calibrator, then the in-station calibrator must be adjusted. The in-station calibrator should be adjusted in the span mode.

4.2.4 Refer to Table 1 for corrective action. Both the current span results and the trends observed during the past week or two should be considered.

4.3 Precision Checks

- 4.3.1 "DOWN" the appropriate channels of the data acquisition system (DAS) to exclude the check from the valid ambient data base. Be sure to "UP" the channels to resume collection following the procedure.
- 4.3.2 Precision checks must be performed at a minimum frequency of once every two weeks. Ideally they are performed in conjunction with but prior to Dynamic Zero and Level 1 span checks. A reference calibrator must be used to perform a precision check.
- 4.3.3 Zero checks are performed with a reference calibrator during each site visit.
- If the analyzer response to zero air is within the zero tolerance limits ($\pm 1\%$ of full scale) adjustment to designated zero response can be performed as necessary.
 - If analyzer response is not within the zero tolerance limits ($\pm 1\%$ full scale), troubleshoot to determine an assignable cause for the difference before adjusting. Possible sources of zero air contamination such as filters and/or scrubbers should be checked before analyzer zero is adjusted. When the zero response is within the tolerance limits, adjustment is considered complete.
- 4.3.4 Test gas must pass through all tubing, filters, scrubbers, etc. employed during normal sampling.
- 4.3.5 Input concentration is 0.08-0.10 ppm (8-10 ppm for CO).
- 4.3.6 Detailed instructions for methods and documentation are found in ENSR SOP 2600-001, Precision and Level One Span Checks.
- 4.3.7 $\Delta\%$ between input concentration and analyzer response is the precision statistic required. If the precision check is rerun after a zero or span adjustment, the original $\Delta\%$ (prior to adjustment) is the result that must be utilized to calculate the quarterly statistics for the site.

4.4 Dynamic Zero Checks (with a reference calibrator)

- 4.4.1 "DOWN" the appropriate channels of the data acquisition system (DAS) to exclude the check from the valid ambient data base. Be sure to "UP" the channels to resume collection following the procedure.
- 4.4.2 Zero checks are performed with a reference calibrator during each site visit.

- If the analyzer response to zero air is within the zero tolerance limits ($\pm 1\%$ of full scale), adjustment to designated zero response can be performed as necessary.
- If analyzer response is not within the zero tolerance limits ($\pm 1\%$ full scale), troubleshoot to determine an assignable cause for the difference before adjusting. Possible sources of zero air contamination such as filters and/or scrubbers should be checked before analyzer zero is adjusted. When the zero response is within the tolerance limits, adjustment is considered complete.

4.4.3 The site zero/span tracking mechanism should be activated each time a zero and Level 1 span check is performed and the results should be compared. Any discrepancy between the site standard and the reference calibrator should be investigated and corrected.

4.5 Level 1 Span Checks

- 4.5.1** Perform Level 1 span checks at least once every two weeks. Frequency should be adjusted on the basis of analyzer performance as indicated by control charts, but must be a minimum of every two weeks.
- 4.5.2** The Level 1 input concentration should be 70-90% of analyzer full scale. The check must be performed using a reference calibrator.
- 4.5.3** "DOWN" the appropriate channels of the data acquisition system (DAS) to exclude the check from the valid ambient data base. Be sure to "UP" the channels to resume collection following the procedure.
- 4.5.4** All Level 1 span and precision checks must be documented on the appropriate calibration data sheet. See ENSR SOP 2600-001, Precision and Level 1 Span Checks, for detailed instructions on methods and documentation.
- 4.5.5** Test gas must pass through all tubing, filters, scrubbers, etc. employed during normal sampling.
- 4.5.6** Compute $\Delta\%$ between analyzer response and input concentration (see Section 4.7.5). The analyzer must respond within $\pm 5.0\%$. Refer to Table 1 for corrective action. If the analyzer is adjusted, record new analyzer reading, new $\Delta\%$ and initial and final span pot setting on the data sheet.

4.6 Multipoint Calibration

A Multipoint Calibration is required:

- upon installation of an analyzer in a field station;
- after repair of a malfunctioning analyzer;
- after replacement of major components of an analyzer;
- prior to removal of an analyzer from a field station, if it is still functioning;
- when $\Delta\% > \pm 10\%$ in an Automatic Span and subsequent Level 1 span check;
- when $\Delta\% > \pm 10\%$ in an audit
- at a maximum interval of 3 months (a performance audit can be used to meet this requirement); and/or
- when directed by an appropriate supervisor.

4.6.1 Input concentrations for multipoint calibrations are as follows:

(ppm)	CO (ppm)
0.000	0.000
0.030...0.080	3.0-8.0
0.150...0.200	15.0-20.0
0.350...0.450	35.0-45.0
0.800...0.900*	80.0-90.0**
*If analyzer is operating in 0-1.0 ppm range	
**If analyzer is operating in 0-100 ppm range	

A multipoint calibration must always leave the analyzer operating within $\pm 5.0\%$ of the reference calibrator at all concentrations.

4.6.2 Refer to the appropriate project-specific ENSR SOP(s) for detailed multipoint calibration procedures.

4.6.3 Verification of the internal zero/span mechanism is required whenever a multipoint calibration is performed.

4.7 Tolerance limits for accuracy for continuous analyzers.

4.7.1 The maximum allowable deviation of analyzer response from input concentration is $\pm 15\%$. When analyzer response to calibration gas at any single point in a calibration check falls outside this limit, the data collected back to the last documented multipoint calibration is designated as suspect.

4.7.2 The minimum adjustable deviation is $\pm 5\%$.

When analyzer responses during a calibration check fall within this limit, the analyzer should not be adjusted.

4.7.3 The maximum deviation for which a single-point calibration is adequate is $\pm 10\%$. When analyzer responses fall outside this limit in a Level 1 span check, a multipoint calibration must be performed.

4.7.4 Adjustment should always leave the analyzer within $\pm 5\%$ at all points checked.

4.7.5 The deviation of analyzer output from input concentration is determined as follows:

$$\Delta\% = \frac{(\text{concentration})_{\text{output}} - (\text{concentration})_{\text{input}}}{(\text{concentration})_{\text{input}}} \times 100$$

- Average the percentage difference for all of the concentrations.
- Note: It is essential that correct signs (plus or minus) be retained during calculation of average percentage difference.
- Compare the percentage difference at each point with the average percentage difference. If the percentage difference at any individual point differs from the average percentage difference by more than 5 percentage points, run the point again. If, on this second run, the point falls within 5 percentage points of the average, accept it and recompute the average. If not, troubleshoot to determine an assignable cause for the difference.

4.8 Data Acquisition System (DAS)

4.8.1 System responses to calibration and calibration check inputs should be retrieved from the DAS. As such, the proper operation of the DAS is verified and documented each time a calibration or check is performed.

4.8.2 Following the stabilization of analyzer response to calibration input, five minute average readings should be observed until two successive responses agree within two or three ppb of each other. This response should be recorded on the calibration form and used to compute percent difference as well as noted on the strip chart recorder.

4.8.3 Instantaneous DAS voltage responses to calibration inputs should be compared to analyzer analog output as observed with a calibrated digital voltmeter to verify agreement between analyzer output and the value reported by the DAS. The DAS should agree within ± 0.002 volts.

4.8.4 If the DAS responds outside this tolerance, an NIST-traceable variable 0-10 volt voltage source should be used to challenge each channel of the DAS using one volt increments. The DAS A/D converters are then to be adjusted as necessary to agree with the designated input within ± 0.002 volts.

- 4.8.5 Voltage inputs and DAS responses as well as test equipment serial numbers and calibration dates should be recorded in the field station log. A calibration seal should be placed on the DAS.

4.9 Strip Chart Recorders

- 4.9.1 Strip chart recorders are to be calibrated at the same time as their associated analyzer(s).
- 4.9.2 DAS responses to calibration or calibration check inputs are to be noted on the strip chart recorder. The notations on the strip chart recorder should explain each significant deflection of the recorder pen, the reason for as well as the beginning and ending times of the period during which the analyzer was not sampling ambient air. The technician performing the procedure should also initial the strip chart recorder along with employee number.
- 4.9.3 A column on the calibration or calibration check data sheet should be labeled "strip chart recorder" and strip chart readings should be expressed as percent full scale and recorded in this column. Note any recorder zero offset.
- 4.9.4 Following stabilization of analyzer response to calibration input, strip chart recorder readings plus or minus any recorder zero offsets must agree with DAS readings within $\pm 1.0\%$. If the strip chart responds outside this tolerance, an NIST-traceable variable 0-10 volt voltage source should be used to challenge the recorder using one volt increments. The strip chart recorder is then to be adjusted as necessary to within $\pm 1.0\%$.
- 4.9.5 Voltage inputs and recorder responses as well as test equipment serial numbers and calibration dates should be recorded in the field station log. A calibration seal should be placed on the strip chart recorder.

4.10 High Volume Sampler Calibration

- 4.10.1 High Volume samplers are to be multipoint calibrated:
- Upon installation
 - every three months
 - following brush or motor change
 - following leak repair
 - following an audit or cal check with results $\pm 7.0\%$
 - prior to take down.

4.10.2 High volume samplers are to be calibrated with an NIST-traceable orifice, either variable or used in conjunction with a set of resistance plates. The orifice must be calibrated for the range at which it is to be used (typically 30 - 60 scfm) except for VFC HI-VOLS and must have been calibrated within the previous twelve months.

4.10.3 Calibration is to be performed in accordance with the Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II Ambient Air Specific Methods Section 2.11.2.

4.11 High Volume Sampler Calibration Checks

4.11.1 For HI-Vols without a flow controller, a one point calibration check is to be performed:

- Monthly
- Prior to brush change or motor change
- Prior to removal
- When two successive filters fail the initial flow criterion of 40-60 acfm
- Whenever HI-VOL operation is suspect (noises, etc.)

4.11.2 The one point check is to be performed using the orifice and 13 hole resistance plate (no manometer is required). If the orifice is variable resistance, perform the check with the orifice adjusted to its lowest resistance (highest flow rate).

4.11.3 Calculate the $\Delta\%$ between the new magnehelic gauge reading and the corresponding original multipoint calibration reading. If the $\Delta\%$ is $>\pm 7.0\%$, investigate the cause and repair and recalibrate as necessary.

4.12 HI-VOLS with MFC or VFC Flow Controllers

4.12.1 For HI-VOLS with a MFC or VFC flow controller, a one point calibration check is to be performed:

- Weekly
- Prior to brush change or motor change
- Prior to removal
- Whenever HI-VOL operation is suspect (noises, etc.)

4.12.2 For the weekly check, use a blank filter (no orifice is required).

4.12.3 Verify that the manometer and magnehelic gauge or flow recorder reading is $\pm 7.0\%$ of the set point. Should the check be observed to be outside this

tolerance, troubleshoot the sampler and recalibrate or reset the flow controller as necessary.

- 4.12.4** For HI-VOLS with size selective heads, the flow setting must be verified each time a new filter is installed. The flow setting must be within ± 4.0 cfm of the "flow controller set point" in order for the sample to be considered valid.

4.13 Meteorological Sensor Calibrations

- 4.13.1** Meteorological sensors shall be calibrated:

- At a minimum interval of every six months
- Upon installation
- Prior to takedown
- In place, if possible
- Following bearing replacement (wind speed and direction)
- Following repair or replacement of any system component which may alter calibration

- 4.13.2** The data acquisition system (DAS) and strip chart recorder will be calibrated at the same time as the associated meteorological sensor.

- 4.13.3** Reconfigure the DAS to isolate the calibration data from the ambient data prior to initiation of the calibration. All system responses to calibration challenges are to be retrieved from the DAS and recorded on the calibration form. Following the calibration, reconfigure the DAS to resume collecting ambient data.

- 4.13.4** DAS responses to calibration inputs are to be noted on the strip chart recorder. The notations on the strip chart recorder should explain each significant deflection of the recorder pen, the reason for as well as beginning and ending times of the calibration period. The technician performing the procedure should also initial the strip chart recorder along with employee number.

- 4.13.5** All test equipment must be calibrated traceable to NIST standards. The calibration standard must have equal or better accuracy and precision than the unit under test (UUT).

- 4.13.6** Record all test equipment on the calibration data sheet by manufacturer, model, serial number and calibration date.

- 4.13.7** Following calibration, calibration stickers must be completed and affixed to each calibrated system. A copy of the completed calibration data sheet shall be left on site.

5.0 QUALITY CONTROL

- 5.1** This procedure describes the requirements necessary to ensure that the output of the field measurement process is traceable to NIST-SRM. Tolerances and action levels are listed in the procedure and summarized in Table 1.
- 5.2** Review
- 5.2.1** Calibration documentation will be reviewed and approved by the supervisor to ensure conformance with this and any other referenced ENSR SOPs.
- 5.2.2** If calibrations are rejected, the operator of the network shall be notified immediately, and corrective action taken. If the calibration was performed by someone other than the network operator, that person shall also be notified.

6.0 DOCUMENTATION

- 6.1** Record all calibration and calibration check documentation in ink, at the time of the calibration or calibration check, on the appropriate calibration forms. Complete all sections of the forms using "NA" (not applicable) if necessary.
- 6.2** Record all appropriate documentation in the field station log and on the strip chart. The notations on the strip chart should explain each significant deflection of the recorder pen (e.g., a calibration point, baseline, amp check, adjustment) as well as the beginning and ending times of the period during which the instrument was not sampling ambient air.
- 6.3** Label the calibrated analyzer sampler or meteorological system with a calibration sticker showing the instrument serial number, date of the calibration, and signature of the operator (Figure 1 is an example of a calibration sticker).
- 6.4** Upon completion of the calibration, distribute documentation as follows:
- 6.4.1** First copy, to supervisor for approval and to the data processing center.
- 6.4.2** Second copy retained in the shelter for field records.
- 6.4.3** Original to the project files.

- 6.4.4 If the calibration is performed by someone other than the routine operators, such as a field service technician or engineer, then the person who performed the calibration should retain a copy of his or her work.

7.0 REFERENCES

- EPA Quality Assurance Handbook for Air Pollution Measurement Systems Volumes I and II.
- Code of Federal Regulations 40 CFR, Part 58, Appendix A, Quality Assurance Requirements for Prevention of Significant Deterioration.

Figure 1

Example of Calibration Sticker

ENSR	CALIBRATION SEAL	
SERIAL NO. _____		
CAL DATE _____	RECAL DATE _____	
TECH _____		

TABLE 1

Tolerance Limits

Check	Tolerance				
	>+1%* Full Scale	>+2% Full Scale	>+5%	>+10%	>+15%
Zero (with reference calibrator)	Adjust	Multipoint cal.	N/A	N/A	N/A
Automatic span	N/A	N/A	N/A	Level 1 span	Level 1 span
Precision/Level 1 span	N/A	N/A	Adjust	Multipoint cal.	Multipoint cal.
Multipoint cal.	N/A	N/A	Adjust	Adjust	Adjust analyzer and invalidate data

APPENDIX

Definitions

Accuracy - The extent to which a measurement or the average of numerous measurements recorded by a single analyzer agrees with the true value. The difference between the true value and the measured value is defined as the error. An analyzer is considered accurate if the error is less than the tolerance or control limits.

Assignable Cause - A cause that can be found and corrected.

Audit - An independent review conducted to compare some aspect of performance with a standard for that performance. A performance audit of a continuous gas analyzer incorporates a calibration check utilizing multiple known inputs; however, it is not a multipoint calibration.

Audit Calibrator - A device other than the in-station calibrator or the reference calibrator that is used only for audits. The audit calibrator must be an EPA-approved transfer standard, in current calibration, capable of producing gases at several concentrations equally spaced over the operating range of the analyzer to be audited. These "test atmospheres" must be traceable to an authoritative standard.

Calibration - The process of establishing the relationship between the output of a measurement process and that of a known input.

Calibration Check - The process of determining the relationship between the output of a measurement process and that of a known input in order to ascertain the extent to which it agrees with the desired relationship.

Calibrator - A device used to generate a known input or range of known inputs.

Control Limit - A value calculated from a sample of test data, and expressed as a hypothetical test value, which defines a limit of random cause in the variation of the test data. Control limits are most often a pair of values defining limits of upward and downward variation.

Example: If the designated automatic span value for a given analyzer-calibrator pair is 80 ppb and the calculations indicate that variations of ± 10 ppb or less are attributable to random cause, then the control limits for these spans are:

Upper - 90 ppb

Lower - 70 ppb

Variations outside control limits are attributable to assignable cause. As used in this SOP, "control" and "tolerance" are nearly identical in meaning.

Data Processing Center - The location and group where data for a network are processed.

In-Station Calibrator - A calibrator integrated with a continuous monitor at a field monitoring site.

Level 1 Span Check - A span check at 70-90% of analyzer full scale, accompanied by a zero check. The standard used for the check must be an NIST-traceable standard. Results of the check are compared to the tolerance and the analyzer is adjusted if the tolerance is exceeded.

Multipoint Calibration - A calibration utilizing (1) multiple known inputs for the initial calibration check to determine linearity and accuracy of response; (2) adjustment or readjustment, if required, based on the tolerance or control limits; (3) a final calibration check to confirm linearity and accuracy of response following adjustment or readjustment; and (4) at least three points and zero.

Precision - The extent to which any individual value in a set of controlled test data can be expected to agree with the average of the set; the variability of data. Precision is not a measurement to determine "how far" from the true value (accuracy), but rather how scattered are the measurements.

Precision Check - An input of 0.08-0.10 ppm of gas (8-10 ppm for CO) using an NIST-traceable calibrator. Actual input concentration and analyzer response are documented, along with calibrator identification. No adjustment is made to the analyzer and the precision check must be performed before any zero or Level I span check. Results are used to compute precision of the data.

Primary Standard - A method, device, or material having known, stable, measurable, traceable and readily reproducible characteristics.

Random Cause - A cause that cannot be isolated and/or attributed to a correctable condition.

Reference Calibrator - A device other than the in-station calibrator that is used to calibrate or check an analyzer in the field. A reference calibrator must be in current calibration and

capable of producing concentrations over the range of the analyzer to be calibrated or checked. This calibrator should be traceable to an authoritative standard.

Span Check - An input generated by a calibrator, usually an in-station calibrator or span cells, to verify analyzer performance. A span check is used to indicate changes in system performance and to demonstrate whether or not the instrument is performing within tolerance or control limits.

Standard Reference Material - A material (such as bottled gas or permeation tube) that has been certified as a primary standard.

Tolerance Limit - A noncalculated limit of variation set by contract, regulatory agency, or by judgement based upon experience (e.g., a known input plus/minus some percentage).

Traceability - Refers to written documentation supporting the accuracy, relative to a primary standard, of a method, device, or material, and the data it produces. Documentation must trace the history of calibration, including dates, methods, and procedures used, back to the relevant primary standard (by number, if NIST-SRM).

Transfer Standard - (Secondary Standard) - A method, device, or material that is calibrated against a primary standard for comparison with a third method, device, or material.

SOP NUMBER: 2630
**Routine Ambient Monitoring Data
Collection and Evaluation**

Date: 2nd Qtr. 1993
Revision Number: 3
Author: Mike Dobrowolski
Discipline: Quality Assurance

1.0 PURPOSE AND APPLICABILITY

- 1.1** This procedure describes the minimum requirements for routine air quality and meteorological data collection and evaluation. The principal objectives are to:
- Assess the status of each monitoring system.
 - Evaluate the quality of data gathered.
 - Document all information relating to validity of data, with particular attention to reasons for invalid or suspect data.
- 1.2** Completion of the following forms are required for all stations:
- Field Station Log
 - Data Assessment Report.
- 1.2.1** Required in addition for ambient air quality parameters:
- Quarterly Multipoint Calibration Data Sheets
 - Bi-weekly Precision Level One Span Data Sheets
 - Multipoint Calibration/Precision Check Data Sheets
- 1.2.2** Required in addition for HI-VOL stations:
- HI-VOL filter jackets.
 - Quarterly Multipoint Calibration Data Sheets
- 1.2.3** Required in addition for meteorological parameters:
- Semi-annual Calibration Data Sheets

2.0 RESPONSIBILITIES
2.1 Field Technician

- 2.1.1** It is the responsibility of the field technician to read and perform the operation in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.

- 2.1.2** It is also the responsibility of the field technician to document the procedure in the field station log as well as on any data forms contained within this procedure.

2.2 Project Manager

- 2.2.1** It is the responsibility of the project manager or designee to ensure that the operation is performed at the designated frequency.
- 2.2.2** It is the responsibility of the project manager or designee to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 REQUIRED MATERIALS

- ENSR SOP 2900, Data Validation
- ENSR SOP 2999, Acoustic Sodar Data Validation/Quality Assurance Auditing

4.0 METHOD

Field Station Logs, Multipoint Calibration Forms, Instrument Specific Checklists and Data Assessment Reports are official program records which may be used in subsequent legal proceedings. Entries must be informative and concise. An analyst, meteorologist, repair person or client may need to use the information weeks or months later.

The purpose of completion of the various documentation forms are:

- To clearly indicate data which are valid, suspect or invalid. Validation criteria are listed in instrument specific calibration SOPs or in the Quality Assurance Project Plan (QAPP).
- For invalid data, to state clearly why the data are no good.
- For suspect data, to provide all information which will aid in the evaluation of data validity.
- To provide the information which may be helpful in analyzing meteorological and air quality conditions, instrument performance and site activities.
- Instructions to complete these forms are discussed below.

4.1 Field Station Log (Figure 1)

- 4.1.1** Technician and all visitors must sign the field station log upon entering and prior to leaving the shelter.

4.1.2 The field station log is used to record all occurrences at the station which may be of significance in later analysis of collected data or following the operational and maintenance history of any of the installed instruments, systems and test equipment. Record the following:

- Calibrations, quality control checks, repairs or replacements of all equipment with corresponding serial numbers.
- A description of non-conformance to requirements listed on any instrument checklist, and action taken, if any.
- A description of abnormal conditions, as discussed in 4.4.3.
- A description of conditions pertinent to "suspect" or "invalid" data.
- Brief summary of other tasks performed.

4.2 Instrument Checklists

- 4.2.1** Checklists are contained within individual ENSR SOPs for the calibration, operation or maintenance of each analyzer, sensor, or system.
- 4.2.2** Instrumentation is to be reviewed for compliance to checklist requirements at time of station visit.
- 4.2.3** The checklist procedures require the entering of a check (✓) (or yes), an actual reading, or a 'NO' for each item. Actual readings are preferred, where appropriate, but are required for out of tolerance conditions.
- 4.2.4** The entering of a 'NO' often indicates that on-site corrective action or notification of project management for corrective action assistance is required. The appropriate action should be taken promptly and described in the field station log.

4.3 Data Assessment Reports (DAR) (Figure 2)

- 4.3.1** The field technician is required to classify all data by date and time, based on specific criteria and THE BEST JUDGEMENT OF THE FIELD TECHNICIAN. This classification is recorded on the Data Assessment Report.
- 4.3.2** DARs are to be filled out immediately upon review of data, whether daily, weekly or other schedule.

4.3.3 Entries on the Data Assessment Report form should include the following:

- Classification of data as suspect or invalid, with time frame of problem clearly marked as to the start and end date and time for each classification.
- Short entries of why data is suspect or invalid. Reference the document which contains the detail of negative findings (i.e., "logs" "Prec. _" "multipoint cal,") with abbreviations whenever possible.

4.4 Routine Air Quality and Guidelines

Certain checks are common to most parameters and are described as follows:

4.4.1 Shelter Status

- 'Temp' - Check the current temperature. Where high-low thermometers are installed, record the high and low temperature since the last visit. Reset the high and low markers if necessary.
- 'Manifold Pump OK?' (air quality shelter only) - Verify that the pump is operating and visually inspect all connections.
- Manifold Clean - Inspect the manifold for accumulation of particles or grime.

4.4.2 "Strip chart time, supply, marked?"

- Is the indicated strip chart time accurate? If the chart requires adjustment to match the time, the chart should be clearly marked before and after adjustment.

NOTE: All ENSR data are logged in LOCAL STANDARD TIME. Exceptions are described in the QAPP.

- Is the chart supply adequate until the next visit?
- Are the date and time of visit and operator's initials clearly marked on the chart?
- "Is ENTIRE prior strip chart OK?" The field technician is to examine the portion of the strip chart generated since the prior examination for normal and anomalous data, based on personal knowledge of weather conditions, proper instrument operation, and zero/span tolerances. This check is most useful if done for instrument diagnostic purposes. It is required only for historical networks in order to assess data validity.

4.4.3 Abnormal Conditions - Indicate local conditions in the field station log which might explain abnormal, but not necessarily invalid, data. conditions worth noting would include precipitation, wind and dust storms, construction, traffic, harvesting or other sources which might increase pollutant concentrations.

4.4.4 Particulate Samplers - Basic checks include proper day sequencing, 24 hour exposure, flows within specification and filter intact. Exceptions should be noted on the filter jacket comments section, and also in the station logs.

4.5 Routine Meteorological Checks and Guidelines

4.5.1 Wind Direction and Wind Speed

- Status - Verify that the sensors are intact, free from ice, and that cups and vane appear to move freely.
- Wind direction data - Verify that strip chart readout, present actual vane position and observed current wind direction agree.
- Wind speed data - Verify that current strip chart value appears to be reasonable based on observation and that the cups are turning appropriately.
- Multiple sensors - Verify wind direction and speed sensors at other elevations at the same site as above, and compare values with the other sensors to see that agree within reasonable limits. The wind directions from top to bottom of a tower will typically agree within 10° to 15° when the wind speed exceeds 10 MPH. The upper level wind speed will normally read approximately 25 to 40% higher than the lowest level. Note observed discrepancies in the log. Flag data for the period as "suspect" on the Data Assessment Report if they are outside these guidelines.

4.5.2 Temperature and Temperature Difference

- Status - Verify, if possible, that the sensor aspirator motors are operating
- Temperature data - Verify that the current value appears correct, based on personal observation.
- Temperature difference data - Verify that the values recorded are reasonable, based on the "normal" conditions listed in Table 1.

4.5.3 Dew Point

- Status - Verify, if possible, that the sensor aspirator motor is working.
- Data - Verify that the dewpoint value is equal to or less than the ambient temperature value, if both sensors are located at the same level.
- For monitoring sites in the northeast or midwest United States, the following guidelines may be used in assessing dew point data: in the winter dew points greater than 60°F are unlikely. Dew points below 0°F are not unlikely during clear, very cold winter weather. During the summer, dew points less than 40°F are unusual.
- In Southeastern and Gulf Coast States during winter, dewpoints below 30°F are unusual but typically occur several times each winter for periods of one to two days. During the summer, dewpoints below 50°F are rare, especially near the coast.
- Note observed discrepancies in field log. Flag data for the period as "suspect" on the DAR.

4.5.4 Net and Solar Radiation

- Spot check and verify the DAS vs. strip chart values.
- Verify that the solar radiation sensor records zero or near zero values at night.
- Verify that the net radiation sensor records zero or negative values at night.
- Verify that there are no shadows cast on the sensor at any time of the day.
- Verify that the sensor is level, that the domes are clear with no condensation present and that the vegetation in the area surrounding and below the sensor is natural.
- Verify that there is no ice or snow on the sensor.

4.5.5 Precipitation

- Verify the DAS vs strip chart values for a recorded event.
- Verify that the instrument recorded a known event.
- Verify that the heater is operational and/or that the gauge is charged with antifreeze for winter operations (weighing bucket).

- Check the gauge for unusual circumstances such as insect or wildlife activity.
- Verify that the gauge is level and has no leaks (weighing bucket).

4.5.6 SODAR

Data collection and evaluation is quite involved with SODAR and consists of an identical level comparison with sensors mounted on a co-located meteorological tower. The details on SODAR data collection and evaluation are found in ENSR SOP 2999, Acoustic SODAR Data Validation/Quality Assurance Auditing. However, basic steps necessary for preliminary evaluation of SODAR data include:

- Check the red LEDs on the front of the amplifier and verify that the amplifier is not in "standby" or "clipping".
- Check the supply of printer paper and add as necessary.
- Listen to the transmitting pulses of the SODAR for any extraneous echoes or attenuation of signal.
- Verify that the heater is operational.
- Examine the antenna array for dirt, snow, ice, insects etc.. Remove any dirt or snow with a broom or vacuum. Take care to not damage the cones during this operation.
- Check the ambient noise levels. Use a noise meter if one is available and compare versus the noise values reported by the SODAR, or check the values that the SODAR is reporting against the ambient levels determined during the site survey.
- Compare the noise values reported for each of the three beams. These values should be virtually the same and less than the site survey maximum of 55 dBL.
- Observe the area surrounding the SODAR to determine if any land use may have changed or if there is any activity in the area which may influence the collection of data.
- Observe the meteorological tower sensors if possible and perform a reasonability check of the tower data.

5.0 QUALITY CONTROL

Not applicable

6.0 DOCUMENTATION

- 6.1** All documentation such as strip chart records, check lists, field station logs and data assessment reports should be assembled and packaged as a group and submitted for data validation at the end of each month.
- 6.2** One copy of each multipart form should be retained on-site for reference.
- 6.3** Following data validation, all original copies are achieved in the project files.

7.0 REFERENCES

Not applicable

APPENDIX

- "Valid" - data for which no evidence exists to cast doubt on its representativeness, accuracy, and reasonableness that is, data which is "good" beyond a reasonable doubt.
- "Suspect" - data for which some evidence exists to cast doubt on its validity such as possible component malfunction, abnormal local conditions, calibration check performance borderline or out of tolerance, etc.
- "Invalid" - data for which evidence exists which is known to have produced erroneous ambient data such as instrument malfunction, power failure, audits, calibrations, repairs, etc.

TABLE 1

Delta Temperature Screening Values

Weather Conditions	Delta Temperature Approximate Readings (200' tower)
Sunny clear day	-0.5°C to -1.7°C (-1.0 to -3.0°F)
Clear calm night	0 to full scale (warmer a top of tower)
Clear breezy night	0 to -0.8°C (0 to -1.5°F)
Cloudy night	+0.3° to -0.8°C (+0.5° to -1.5°F)

Site _____

Network

Project Number _____

DATE	TIME	COMMENT	INITIALS	EMP. NO.

WHITE COPY – DATA REDUCTION & ANALYSIS · YELLOW COPY – FIELD OPERATION SUPERVISOR · PINK COPY – FIELD STATION LOG BOOK

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SOP NUMBER: 2630

Figure 2 Data Assessment Report

DATA ASSESSMENT REPORT

Project No.: _____ Client: _____ Network: _____ Site: _____ Idea Par. Code: _____
 Sensor S/N: _____ Dates in Service: _____
 Replacement Sensor S/N: _____ Dates in Service: _____
 Level 1 (NBS) Calibration S/N: _____ Gas Standard S/N: _____ Tracking Device S/N: _____
 Month: _____ Year: _____

Day	Hour Ending																								Remarks
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
1																									
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Code: I = Invalid M = Maintenance MP = Multipoint Cal. Field Tech: _____ Date: _____
 S = Suspect PC = Precision Ck. PO = Power Out
 SC = Strip Chart Data Loss ZS = Zero/Span Ck. A = Audit Supervisor: _____ Date: _____

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SOP NUMBER: 2660
Meteorological Sensor Siting and Calibration

Date: 1st Qtr. 2007
Revision Number: 3
Author: Leo Gendron
Discipline: Air Monitoring

1.0 PURPOSE AND APPLICABILITY

- 1.1** Siting of meteorological instruments will be accomplished in accordance with the EPA Ambient Monitoring Guidelines for PSD (EPA -450/4-87-007, May 1987) and EPA's document entitled "Meteorological Monitoring Guidance for Regulatory Modeling Applications" dated February 2000 (EPA-454/R-99-005).
- 1.2** This standard operating procedure (SOP) describes siting requirements such as horizontal and vertical probe placement and exposure considerations such as spacing from obstructions for the installation of meteorological towers and instrumentation. As a general rule, an instrument should be sited away from the influence of obstructions such as buildings and trees, and in a position to make measurements that are representative of the general state of the environment in the area of interest.
- 1.3** Secondary issues such as accessibility and security must be considered, but should not be allowed to compromise the quality of the collected data. Approval for site selection should be obtained from the permit granted agency prior to installation. Any deviation from standard siting and the reasons for the deviation should be described in the Monitoring or Quality Assurance Project Plan (QAPP). An annual site inspection is recommended to verify the siting and exposure of the instrumentation.
- 1.4** General elements of calibration procedures for meteorological instrumentation are discussed, however specific guidance for individual measurement systems are contained in the SOPs referenced in Section 3.

2.0 RESPONSIBILITIES

- 2.1** The project manager/engineer or a professional meteorologist is responsible for instrument siting and installation specifications, and for advising the client on acceptability of siting and installations specified/installed by others.
- 2.2** Technician or engineer performing calibration is responsible for conformance to this procedure.

- 2.3** Project engineer is responsible for quality control review of all calibration documentation, to assure conformance with written procedures, completeness and legibility of results, and final values within specifications.

3.0 REQUIRED MATERIALS

Specific calibration procedures for individual meteorological parameters are further defined in the following ENSR SOPs:

- Vertical Wind Speed - SOP 2660-075
- Wind Direction - SOPs 2660-150 & 2660-166 & 2660-185
- Wind Speed - SOPs 2660-151 & 2660-165 & 2660-185
- Precipitation - SOP 2660-152
- Dewpoint - SOP 2660-155
- Temperature/Delta Temp. - SOPs 2660-210 & 2660-220
- Solar Radiation - SOP 2660-305
- Net Radiation - SOP 2660-320

4.0 METEOROLOGICAL SENSOR SITING

4.1 Wind Direction/Wind Speed

- 4.1.1** The standard exposure height of wind instruments over level, open terrain is 10m above the ground. Open terrain is defined as an area where the distance between the instrument and any obstruction is five to ten times the height of that obstruction. The slope of the terrain in the vicinity of the site should be taken into account when determining the relative height of the obstruction. An obstruction may be man-made (such as a building or stack) or natural (such as a hill or a tree). Where such an exposure cannot be obtained, the anemometer should be installed at such a height that it is reasonably unaffected by local obstructions and represents the approximate wind values that would occur at 10m in the absence of the obstructions.
- 4.1.2** If wind instruments must be mounted on a building (or other large structure) due to the lack of suitable open space, then the measurement should be made at sufficient height to avoid the aerodynamic wake area. This height can be determined by on-site measurements (e.g., smoke releases) or wind tunnel studies. As a general rule, the total depth of the building wake is estimated to be approximately 2.5 times the height of the building.
- 4.1.3** Sensors mounted on towers are frequently used to collect wind measurements at more than one height. To avoid the influence of the structure itself, closed towers, stacks, cooling towers, and similar solid

structures should not be used to support wind instruments. Open-lattice towers are preferred. Towers should be located at or close to plant elevation in an open space representative of the area of interest.

- 4.1.4 Wind instruments should be mounted on booms at a distance of at least twice the diameter/diagonal of the tower (from the nearest point on the tower) into the prevailing wind direction or wind direction of interest. A wind sensor mounted on top of a tower should be mounted at least one tower diameter/diagonal above the top of the tower structure.

4.2 Temperature, Temperature Difference, and Dewpoint Temperature

- 4.2.1 The recommended vertical heights for probe placement are 2m for temperature and 10m and 2m for temperature difference. For sites that experience large amounts of snow, adjustments to the temperature measurement height may be necessary, but the temperature probe should not be above 10m.
- 4.2.2 The sensor should be located over an open, level area at least 9m in diameter. The surface should be covered by short grass, or the natural earth surface. Instruments should be protected from thermal radiation (from the earth, sun, sky, and any surrounding objects) and adequately ventilated using aspirated shields.
- 4.2.3 Temperature sensors on towers should be mounted on booms at a distance of about one diameter/diagonal of the tower (from the nearest point on the tower). In this case, downward facing aspiration shield are necessary.
- 4.2.4 Temperature sensors should be located at a distance of at least four times the height of any nearby obstruction and at least 30m from large paved areas. Other situations to avoid include: large industrial heat sources, rooftops, steep slopes, sheltered hollows, high vegetation, shaded areas, swamps, areas where frequent snow drifts occur, low places that hold standing water after rains, and the vicinity of air exhausts.

4.3 Precipitation

- 4.3.1 Rain gages should be sited on level ground so the gage openings are horizontal and open to the sky. The underlying surface should be covered with short grass or gravel. The height of the opening should be as low as possible (minimum of 30 cm), but should be high enough to avoid splashing in from the ground.

4.3.2 Rain gages mounted on towers should be located above the average level of snow accumulation.

4.3.3 The best exposure may be found in orchards, openings in a grove of trees, bushes, or shrubbery, or where fences or other objects act together to serve as an effective wind-break. As a general rule, in sheltered areas where the height of the objects and their distance to the instrument is uniform, their height (above the instrument) should not exceed twice the distance (from the instrument). In open areas, the distance to obstructions should be at least two, and preferably four, times the height of the obstruction. It is also desirable in open areas which experience significant snowfall to use wind shields.

4.4 Radiation (Solar/Net)

4.4.1 Pyranometers used for measuring incoming (solar) radiation should be located with an unrestricted view of the sky in all directions during all seasons, with the lowest solar elevation angle possible. Sensor height is not critical for pyranometers. A tall platform or rooftop is a desirable location.

4.4.2 Net radiometers should be mounted about one meter above the ground. The groundcover under the radiometer should be natural.

4.4.3 Pyranometers should be located to avoid obstructions casting a shadow on the sensor at any time. Also, light colored walls and artificial sources of radiation should be avoided.

4.4.4 Net radiometers should also be located to avoid obstructions to the field of view both upward and downward.

4.5 Complex Terrain, Coastal and Urban Siting Guidance

4.5.1 Specific siting recommendations cannot be given to cover all possible situations in complex terrain. The process of siting instruments in complex terrain should begin with defining the variables that are needed for a given application. The process should also include defining what terrain influences are likely to be important, using information from topographic maps in conjunction with preliminary estimates of expected plume height range, and any nearby meteorological data. Alternative measurement locations and techniques should then be identified and an optimum design selected by balancing the advantages and disadvantages of the various options.

- 4.5.2 Special siting considerations also apply to coastal and urban sites. Multiple sites are often desirable in these situations, but model input limitations usually require selection of a single "best" site for modeling applications. Judgements on siting in these special situations should be made in consultation with the appropriate Regional Office.
- 4.5.3 For further details on meteorological sensor siting for complex terrain, coastal or urban situations, refer to EPA's Document entitled "On-Site Meteorological Program Guidance for Regulatory Modeling Applications".

4.6 SODAR Siting Guidance

4.6.1 Basic guidance for siting a SODAR unit is as follows:

- The antenna must be placed less than 50 meters from the main computer
- The antenna location must be as quiet as possible
- The antenna location must be as far as possible from any objects (i.e. trees, telephone lines, electric lines, fences, etc.) which could generate whistling noises in strong wind conditions
- The antenna location must be as far as possible from any object capable of reflecting echoes (i.e. towers, buildings, hills or cliffs, etc.). The angle between horizontal and a line joining the antenna pad and the top of the obstacle must be less than 15°.
- Large electric or magnetic fields should also be avoided.

4.6.2 In addition to general meteorological siting considerations, the fundamental requirements of a return signal with a sharply defined atmospheric peak frequency places special requirements on the siting of a SODAR system.

4.6.3 External noise sources can be classified as active or passive, and as broad-band (random frequency) or narrow-band (fixed frequency). General background noise such as highways or industrial facilities are considered active and are broad-band. If loud enough, they can cause the SODAR software to reject data because it can't find a peak or because the signal-to-noise ratio is too low. The net effects are not to produce erroneous data but to lower the effective sampling rate due to the loss of many of the pulses.

4.6.4 Active, narrow band noises sources include birds and insects, or rotating fans. If these noise sources have a frequency component in the SODAR operating range, they may be interpreted as good data by the SODAR.

- 4.6.5** Passive noise sources are objects either on the ground or elevated such as tall towers or buildings and trees. These sources can reflect a transmitted pulse back to the SODAR antenna which will interpret it as good data.
- 4.6.6** A qualitative survey should be conducted to identify potential noise sources, and a quantitative noise survey may be necessary to determine if noise levels are within the manufacturer's minimum requirements.
- 4.6.7** Potential passive sources should be mapped and identified in terms of direction and height from the antenna. Data should be reviewed for potential biases resulting from passive reflectors.
- 4.6.8** One last item that should be considered in a SODAR siting decision is the effect of the instrument on its surroundings. The sound pulse is quite audible and could create a disturbance if antennas are located too close to residences.

4.7 General Siting Guidance

If the siting recommendations contained in this SOP cannot be achieved, then alternate approaches should be developed in conjunction with the EPA/State Regional Office. Approval for a particular site selection should be obtained from the permit granting agency prior to installation of any meteorological monitoring system.

4.8 Meteorological Sensor Calibrations

4.8.1 Test Equipment shall

- be identified on the calibration data sheet by manufacturer, model number, serial number, and most recent calibration date
- comply with provisions for out-of-date calibration as in SOP 2750, Test Equipment Calibration/Repair

4.8.2 A reference calibration unit must have equal or better accuracy and precision than the unit under test (UUT). When two different reference units are used, the one with the better accuracy and precision shall be designated as the standard.

4.8.3 Calibrations of test equipment and standards shall be traceable to NIST or other authoritative standards.

4.8.4 Sensors shall be calibrated

- in place, whenever feasible

- upon installation
- prior to takedown
- at a minimum interval of every six months
- after bearing replacement (wind speed and direction)
- after repair or replacement of any system component affecting calibration.

4.8.5 Recorders and data collectors shall be calibrated at the same time as the meteorological sensors.

4.8.6 Digital data acquisition system (DAS) will be reconfigured to isolate the calibration data from the ambient data prior to initiation of calibration procedures. Following calibration the DAS will be reconfigured to resume collecting ambient data.

4.8.7 Strip charts will be annotated such that all non-ambient data will be clearly identified.

4.8.8 Calibration stickers shall be affixed to each calibrated component and/or system in a clearly visible place wherever practical.

4.8.9 A copy of each completed calibration sheet shall be left on site, whenever "NCR" forms are used. If single sheets are used and no copier is convenient, copies will be made by the supervisor and returned promptly to the field site. If errors are found during QC review, corrections will likewise be forwarded to the field.

4.8.10 Significant problems and action items will be telephoned or relayed in person to the cognizant supervisor as soon as practical.

4.8.11 Completed original copies and narrative trip reports shall be approved by the supervisor and stored in the project files.

5.0 QUALITY CONTROL

Any deviation from standard siting and the reasons for the deviation should be described in the Monitoring or Quality Assurance Project Plan (QAPP).

Prior to the collection of data, a systems audit of the meteorological monitoring network should be performed to verify adherence to the requirements presented in the monitoring/QAPP and this SOP. The systems audit should document instrument placement,

surrounding terrain, distance to obstructions, cross arm orientation, proper operation of the data acquisition system, tower condition, calibration and operations maintenance, documentation of deviation from standard siting criteria, or any other conditions which may influence the collection of representative data. Subsequent to the initial audit, succeeding systems audits should be conducted on an annual basis.

6.0 DOCUMENTATION

6.1 Calibration data sheets shall contain

- a complete inventory of test equipment used listed by manufacturer, serial number and calibration date as well as reference units used
- both "as found" and "as left" conditions, including the total system error "as found" (sum of individual component errors)
- tolerance limits for each critical measurement
- serial numbers (both manufacturer's and ENSR's when available) of each sensor and component calibrated
- a copy of each completed calibration sheet shall be left on site.

6.2 Field Station logs shall contain

- name or initials and ENSR employee numbers of each member of the meteorological team
- Data logger channel up/down times
- personnel time in and out each day
- brief description of activities, including parameters calibrated, problems, and out-of-specification conditions found, corrective actions taken, and recommended future action.

SOP NUMBER: 2750

Test Equipment Calibration/Repair

Date: 2002

Revision Number: 1

Author: L. Gendron

Discipline: Air Measurements

1.0 PURPOSE AND APPLICABILITY

The following equipment calibration/repair procedure applies to any piece of test equipment which is used as a secondary standard for the calibration or repair of instrumentation requiring traceability to the National Bureau of Standards (NBS). This procedure does not necessarily apply to test equipment used for research and development projects.

2.0 RESPONSIBILITIES

2.1 The Engineering Division shall specify qualified calibration service organizations with NBS traceable equipment to calibrate and/or repair test equipment. The service organization shall be selected so as to provide:

2.1.1 A record of calibration data similar to the Appendix copy,

2.1.2 A certificate of NBS traceability similar to the Appendix copy.

2.2 Users of test equipment, either in a laboratory or in the field, are responsible for maintaining the proper calibration schedule (see Appendix 1) of their equipment and notifying their supervisor of any need for replacement equipment.

2.3 Laboratory or District Supervisors are responsible for arranging for replacement of equipment when notified that test equipment is due for calibration or out for repair.

2.4 The person issuing a purchase requisition for test equipment shall specify "certification of traceability to NBS required." A copy of the purchase order shall be forwarded to the Quality Assurance (QA) library.

2.5 Upon receipt of new test equipment, Materials Control shall submit the certification of traceability to the QA library.

3.0 METHODS

3.1 Calibration of test equipment will be performed at scheduled intervals with a two week grace period for scheduling purposes. The interval will be that recommended in the

ERT Engineering Bulletin dated April 1979 (Appendix). Any data generated through use of a piece of test equipment beyond its two-week calibration grace period will be considered "suspect" until the results of the recalibration are investigated.

3.2 In the event that any of the following apply, the laboratory or district supervisor shall be notified immediately and the equipment removed from service until recertification can be completed.

3.2.1 A piece of test equipment does not have a valid calibration sticker.

3.2.2 A calibration seal is broken.

3.2.3 A unit is found to be out of calibration or to require repair.

4.0 DOCUMENTATION

Associated with each piece of test equipment is an Instrument Record Card, ENSR Form 1828 and 1828-1 (Appendix 4) or an older version of the IR Card, ENSR Form 1172 (see TechIN #2901-001). These cards are maintained in the QA library and in laboratories by instrument type and manufacturer's serial number. Originals of calibration and repair data and certification records are filed with the card. '

APPENDIX I **RECOMMENDED CALIBRATION FREQUENCY**

Manufacturer	Model No.	Item	Recommended Cal Cycle # of Months
Dana	2000	Digital Multimeter	6
Dana	5000	Digital Multimeter	6
Exact	126	Function Generator	12
Exact	190	Function Generator	6
Fluke	881A	Differential Voltmeter	6
Fluke	1900A	Counter	6
Fluke	1952A	Counter	12
Fluke	8000A	Digital Multimeter	12
Fluke	8020A	Digital Multimeter	12
Fluke	8030A	Digital Multimeter	6
Fluke	8040A	Digital Multimeter	6
Fluke	8100A	Digital Multimeter	6
Fluke	8120A	Digital Multimeter	6
Fluke	8600A	Digital Multimeter	6
Gen. Radio	1433-F	Resistance Decade	6
Gen. Radio	1531	Strobotac	6
Gen. Res.	DAS-57AL	Dial-A-Source	6
Gen. Res.	RDS-63A	Resist-O-Stat	6
Heath	EU-80A	Voltage Reference Source	6
H.P.	400FL	AC Voltmeter	6
H.P.	1702A	Oscilloscope	12*
H.P.	87	Digital Multimeter	6
H.P.	2801	Thermometer	12
Keithley	168	Digital Multimeter	6
Keithley	225	Current Source	6
Keithley	261	Pico Amp Source	6
Keithley	414A	Pico Emmeter	6
Keithley	616	Electrometer	6
Newport	210	Digital Panel Meter	6
Philips	PM3110	Oscilloscope	12*
Philips	PM3210	Oscilloscope	12*
Power	781	Torque Meter	6**
Philips	PM3232	Oscilloscope	12*
Simpson	260	Volt-Ohm-Meter	12*

Simpson	261	Volt-Ohm Meter	12*
Simpson	715	RMS Voltmeter	12*
Tek	212	Oscilloscope	12*
Tek	453	Oscilloscope	6
Tek	422	Oscilloscope	12*
Tek	TM515	Power Supply	12*
Tek	T922	Oscilloscope	12*
Tek	DC503	Counter	6
Tek	DM501	Digital Multimeter	6
Tek	FG503	Function Generator	12
Tek	SC502	Oscilloscope	12*
Telequipment	D75	Oscilloscope	12*
Triplett	630	Volt-Ohm-Meter	12*
Waters	651C-1	Torque Watch	6
Waters	366-2M	Torque Watch	6
Waters	366-3M	Torque Watch	12
Weston	1241	Digital Multimeter	6

*Functional check.

**Instrument used infrequently; recommended calibration schedule dependent on use schedule.

SOP NUMBER: 2900

**Field Audit of Air Quality
Monitoring Networks****Date:** 4th Qtr. 2006**Revision Number:** 1**Author:** Mike Dobrowolski**Discipline:** Air Measurements**1.0 PURPOSE AND APPLICABILITY**

The purpose of this procedure is to outline the procedures and considerations necessary to conduct a field audit of air quality monitoring networks. The protocol serves as a suggested guideline and is not intended to be a detailed step-by-step instruction. Specific procedures and required materials can be found in the ENSR SOPs listed in Section 3. Auditors should feel free to ask as many questions as necessary to make an evaluation of the quality of the program audited.

The field audit described in this procedure has been designed primarily for PSD (Prevention of Significant Deterioration) field monitoring programs. Audits for other kinds of programs will consist minimally of verification of compliance with project specific Quality Assurance Program Plans, regulations, and permit requirements.

2.0 RESPONSIBILITIES

The auditor shall be responsible for:

- 2.1** Performing the audit in compliance with the guidelines and procedures presented in this SOP and ENSR SOP 2900-001, Performance Audits of Air Quality Monitors.
- 2.2** Reviewing the Quality Assurance Program Plan, if available, to become familiar with the system design, the purpose of the monitoring, and applicable operating procedures.
- 2.3** Maintaining familiarity with the calibration equipment used in the field as well as the monitoring equipment audited. Certification of the auditor on the operation of the calibrators used may be desirable.
- 2.4** Assuring that all calibration equipment used for the audit has been certified within required time limits (see ENSR SOP 2600, Field Calibration Control Plan) and that all test equipment is in current calibration. (See ENSR SOP 2750, Test Equipment Calibration/Repair.)

3.0 REQUIRED MATERIALS

Specific procedures and required materials to fulfill the requirements of this SOP can be found in the following:

ENSR SOP 2600, Field Calibration Control Plan
ENSR SOP 2620-001, High Volume Sampler Calibration
ENSR SOP 2750, Test Equipment Calibration and Repair
ENSR SOP 2900-001, Performance Audits of Air Quality Monitors

4.0 METHOD

4.1 System Audit

See attached six page System Audit Checklist

The auditor shall:

- 4.1.1** At the site (or sites), verify that the site location and configuration match those in the Monitoring Plan. Document any variances and note whether or not required approvals were granted.
- 4.1.2** Verify that all air monitoring instrumentation probes are located at the proper heights and exposures (for PSD, they must meet the probe siting criteria as contained in 40CFR58, Appendix E). If any probe is not properly sited it should be determined whether there is documentation of an approved variance.
- 4.1.3** Verify that meteorological instruments are located at appropriate heights and distances from obstacles for the surrounding terrain. (See Ambient Monitoring Guidelines for PSD, Section 4.2.) If meteorological instruments are not properly sited, it should be determined whether there is documentation of an approved variance.

Note tower and guy wire conditions and observe (when possible) whether tower instruments appear to be operating properly.
- 4.1.4** Inspect the shelter and surrounding area noting accessibility (road conditions), cleanliness, orderliness, shelter temperature control, and

OSHA safety standards pertaining to electrical connections, ladders, railings, and storage of combustible and toxic gases.

- 4.1.5 Inspect the sampling train for leaks, kinks, and visible contamination and moisture. Assure that all ports of the sampling manifold are used or capped off. Verify air flow through the sampling manifold.
- 4.1.6 (Optional) Inventory all monitoring and recording equipment by manufacturer, model number, serial number, age (if available) and date of last calibration, where appropriate.
- 4.1.7 Determine that all air quality monitors in use are certified as reference or equivalent instruments (if required by program) and that they are being operated as such with respect to range, time constant, etc.. If they are not, there should be documentation of an approved variance.
- 4.1.8 Verify that all meteorological systems (digital or analog) meet minimum accuracy requirements as indicated by manufacturer's and applicable guideline specifications; also that each met sensor meets the appropriate specifications (PSD, see Ambient Monitoring Guidelines for PSD, Section 5.2 and references therein).
- 4.1.9 Verify that all instruments are in current calibration. There should be documentary evidence showing that all calibrations are traceable to NIST or equivalent standards.
- 4.1.10 Ascertain whether the site is operated under written or "oral" procedures. Written procedures should be available on site for the technician's reference. The written procedures should be adequate to ensure data validity. The technician may be evaluated as to his knowledge of current procedures.
- 4.1.11 Review site documentation (logs, maintenance schedules, calibration documents, calibration stickers) to assure that procedures are being followed.

4.2 Continuous Analyzer Performance Audit

- 4.2.1 Reconfigure the data acquisition system such that audit challenges are excluded from the valid ambient database.

- 4.2.2** Attach the sample intake line to the vented calibrator outlet line or manifold, including all filters and scrubbers in the normal sample train. (Some stations have provision for attachment at sampling manifold.)
 - 4.2.3** Run at least 3 points and zero, covering the operating range of the analyzer. (See ENSR SOP 2900-001, Performance Audit of Air Quality Monitors)
 - 4.2.4** Calculate the percent different between designated (audit) values and observed values as reported by the digital data logger and/or strip chart recorder; use direct voltage readout from the analyzer only in real-time networks. If major discrepancies exist between redundant data collection systems, note in audit report.
- 4.3** Particulate Sampler Audit
 - 4.3.1** Record ambient temperature and barometric pressure. ENSR SOP 2620-001 for detailed audit procedures as well as for elevation corrections to barometric pressure.
 - 4.3.2** For samplers without flow-control devices, run at least a 1 point calibration using an orifice calibration device and a single blank filter. Compare the flow as determined with the audit calibrator in scfm with the true cfm as read from the current calibration curve for that sampler. Calculate the % difference.
 - 4.3.3** For samplers with flow controllers, use the orifice calibration device with a single blank filter. Compare audit flow with the visual flow indicator (if any) or the assumed true flow. Calculate the % difference. A second point may be run with 2 blank filters, in order to check efficiency of flow controller. The two readings should agree to $\pm 10\%$.
 - 4.3.4** Collocated samplers (PSD) shall be audited. Verify that the sampling frequency of the collocated HI-VOL conforms to the PSD Regulations (Appendix A, 40CFR part 58).

4.4 Data Reduction Audit

- 4.4.1** Determine if procedures exist (written or "oral") for the reduction of raw data to reporting format. These procedures should be adequate to ensure data validity and should cover Quality Control criteria, methods, and documentation. It should be determined whether data are collected digitally or on strip charts and if on both, which is used to report data. The following questions shall be asked: Is there a written procedure for hand-digitizing strip chart values? What averaging method is used (10 min, 30 min, 60 min, etc.)? How many values are included in the average? Is start, center, or end of average interval used to report data? What kind of spot checking, if any, is done?
- 4.4.2** Determine whether calibration documents are used in the validation process, if data are ever adjusted for any reason, and if so, what methods are used and how they are documented.
- 4.4.3** Determine under what conditions the periodic zero and span checks are done (automatic or manual), whether the span values are plotted or logged, and how the span data are used in data reduction.

5.0 QUALITY CONTROL

Not applicable.

6.0 DOCUMENTATION

- 6.1** A copy of the completed performance audit data sheet for each instrument audited will be left on site.
- 6.2** The original of each performance audit data sheet as well as the completed systems audit checklist shall be sent to Quality Assurance in Acton, MA for generation of the audit report.
- 6.3** Audit Report
 - 6.3.1** Audit reports shall contain the results of the performance audit and may also include a checklist with notations made at the site(s), an evaluation of the overall effectiveness of the agency's data collection activities, and an

estimate of the probability of collecting "valid data," based on factual observations.

- 6.3.2 For PSD, the audit report shall contain calculations of accuracy and precision done in accordance with 40CFR58, Sections 4.2 and 5.2.
- 6.3.3 Audit reports shall be issued promptly and addressed to the division manager of the audited area, or to the Program Manager in the case of program-specific audits. Copies will also be sent to those involved in the audited function, to those with profit and loss responsibility, and to the Corporate Quality Assurance Officer.
- 6.3.4 The audit report, including the original data sheets from the performance portion of the audit, will be archived in the ENSR Quality Assurance Library.

7.0 REFERENCES

- Code of Federal Regulations 40 CFR Part 58 Appendix A, October 2006
- Quality Assurance Handbook for Air Pollution Measurement Systems Volume II EPA-600/4-77-027a Section 2.0.11.

SOP NUMBER: 2990

Ambient Monitoring Data Validation

Date: 3rd Qtr. 2006

Revision Number: 5

Author: Vincent Scheetz

Discipline: Air Measurements

1.0 PURPOSE AND APPLICABILITY

- 1.1** This standard operating procedure (SOP) defines the criteria and the process for determining the validity of continuous air measurements data. It is applicable to all validation, regardless of the person or group performing the function.

It is a quality assurance function which requires a person different from the field operator to review blocks of data and the documentation of data collection activities and to accept or reject data based on an established set of criteria. This procedure is based on the EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volumes I, II, and IV.

- 1.2** The criteria and methods described in this SOP are applicable in all programs where more stringent criteria or more elaborate methods of data validation are not imposed by a project-specific document such as a Quality Assurance Project Plan (QAPP). The QAPP will clearly define the project and tasks to which it applies and will discuss the criteria which deviate from standard procedures, along with the reasons for such deviations.
- 1.3** Validation of particulate data is discussed in ENSR SOP 2629-201, Filter Processing Method for the Determination of Total Suspended Particulates. Validation of SODAR data is presented in ENSR SOP 2999, Acoustic SODAR Data Validation/Quality Assurance Auditing.
- 1.4** Valid Data are those data which are suitable for intended use with respect to completeness (data capture or enough time to make a valid hour, month, etc.), representativeness (proper siting, appropriate measurement), accuracy and precision (calibration, instrument performance), comparability (use of standard methods, units, etc.), and traceability (documented linkage to time and location of measurement, and to authoritative standards).
- 1.5** Validation is the process of confirming each of the above characteristics by measuring them against the requirements of the regulatory agency (if any), the client, and ENSR standards of performance. The process includes data reduction, handling, editing, checking, and review, as well as audits and inspections.

Representativeness should be confirmed by auditing the siting with respect to the approved monitoring plan.

- 1.6 Completeness - The absolute minimum portion of an hour that can represent a valid hourly average is 30 minutes for meteorological parameters and 45 minutes for continuous pollutant monitors. Minimum completeness criteria for other averaging periods are listed below:

<u>Averaging Period</u>	<u>Minimum</u>
1-hour	30 min for meteorology, 45 min for continuous air quality
3-hour	3 valid hours
8-hour	6 valid hours
24-hour	18 valid hours

2.0 RESPONSIBILITIES

- 2.1 The field operator is responsible for the first phase of data validation, wherein first-hand knowledge of instrument performance to prescribed tolerances is required to determine data quality. Documentation of the operator's data assessment is critical to validation. The operator shall use the criteria presented in ENSR SOP, the project-specific monitoring plan and/or QA Plan, and the instrument manufacturer's documentation.
- 2.2 The immediate supervisor (supervisor, project manager, project engineer, etc.) is responsible for the second phase of data validation, in which the field documentation and operator data assessment are reviewed to ensure adherence to tolerances and procedures, and to provide the review essential to quality control. The extent of this review shall be determined by the contract, but shall assure that the minimum standards described in this procedure are accomplished.
- 2.3 The project manager is responsible for assigning a qualified individual to perform the validation activities in conformance with this procedure, to the extent defined in the contract and in the QA Plan.

3.0 REQUIRED MATERIALS

- ENSR SOP 2400, Traceability of Standards
- Project-Specific Monitoring Plan or Quality Assurance Plan

4.0 METHOD

4.1 Minimum Data Acceptance Criteria for Air Quality Analyzers

- 4.1.1 The entire sampling system must be demonstrated to be operating properly. Instruments shall be calibrated according to applicable requirements of ENSR SOP, the project-specific monitoring and/or QA Plan, and manufacturer's instruction manuals.
- 4.1.2 The data must be bracketed by instrument calibrations. The data shall be reviewed in blocks beginning and ending with a calibration.
- 4.1.3 The calibrator used (i.e., transfer standard) shall have been calibrated in accordance with ENSR SOP (2400, Traceability of Standards) and manufacturer's instruction manuals.
- 4.1.4 The data must be completely identified with respect to time, site, parameter, scale and units.
- 4.1.5 The accuracy of the data, as indicated in the beginning and ending calibration, must be within the accuracy goals stated in the monitoring plan and/or quality assurance plan for the data to be considered valid.
- 4.1.6 Documentary evidence of the traceability of the data must exist in sufficient detail to substantiate the measurements. The minimum requirements are defined in the monitoring plan and/or QA Plan for each project, but usually include the calibration data sheets, the field logs or status/data assessment sheets, and chain-of-custody records, if appropriate.
- 4.1.7 Data meeting all the criteria (4.1.1-4.1.6) are considered valid.
- 4.1.8 If any of the information necessary to make the above evaluations is not available, the data shall be considered suspect until further review, comparison or investigation demonstrates that the data are valid or invalid.
- 4.1.9 Data covered by 4.1.8 shall be considered valid if no conclusive evidence to the contrary can be found.

4.2 Minimum Data Acceptance Criteria for Meteorological Sensors

- 4.2.1 Meteorological sensors and systems must be demonstrated to be operating properly and be calibrated according to the applicable ENSR SOP and manufacturer's instruction manuals.
- 4.2.2 The data must be bracketed by calibrations or tests which document that the systems are performing within the tolerances specified in the project's monitoring plan and/or QA Plan.
- 4.2.3 The data must be completely identified with respect to time, site, parameter, scale and units.
- 4.2.4 There must be sufficient documentary evidence in the form of calibration data sheets, field station log entries or status/data assessment sheets to support the validity of the data. Minimum requirements are defined in the project-specific monitoring plan and/or QA Plan.
- 4.2.5 Data which meet the criteria described in Sections 4.2.1 - 4.2.4 are considered valid.
- 4.2.6 Data for which any information required in 4.2.4 is missing will be considered suspect until further review, investigation or comparison demonstrates that the data are valid or invalid.
- 4.2.7 Data covered by 4.2.6 shall be considered valid if no conclusive evidence to the contrary can be found.

4.3 Data Correction

- 4.3.1 In rare circumstances, data may have a known quantifiable bias. They may be corrected only if all of the following conditions are met:
 - The bias must have an identifiable cause.
 - The bias must have a clearly defined beginning and ending time.
 - The data in question must meet the criteria of 4.1.1 - 4.1.4 or 4.2.1-4.2.4.
 - The data must be greater than the LDL of the instrument (air quality data only).

Some examples of a quantifiable bias are improper scale factor for data reduction, incorrect analysis of gas cylinder used for calibration, and clearly documented analyzer zero drift.

- 4.3.2 When any data corrections are made (baseline adjustments or any other justifiable adjustment), all audit or precision calibration results, performed during the period of data adjustments, should also be adjusted by the same amount as the data. This procedure will adjust the audit and precision data to accurately reflect the true accuracy of the monitored data residing in the valid data base.

5.0 QUALITY CONTROL

This procedure provides for the validation of air quality and meteorological monitoring data. As such, it is itself a quality control procedure.

6.0 DOCUMENTATION

- 6.1 The original, unedited data shall remain retrievable following validation, and the rationale and methodology associated with any differences between the original data and the final validated data shall be permanently documented.
- 6.2 All validated data and associated reports will remain in the project files for a period to be determined on a project-specific basis.

7.0 REFERENCES

- EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volumes I, II, and IV.

SOP NUMBER: 2991**Continuous Air Measurement Data
Reduction and Editing****Date:** 2nd Qtr., 1993**Revision Number:** 1**Author:** Leo Gendron**Discipline:** Air Measurements**1.0 APPLICABILITY**

This document describes the standard ENSR procedures for the reduction and editing of continuous air quality and meteorological data. The specifics of where this process occurs (i.e., the field or in the office) and by whom will be omitted. These factors are determined by the specific project request.

The procedures described herein are applicable to most air measurements programs. More stringent or more elaborate procedures may be dictated by the QA program plan for a specific project or by client request. Otherwise, this procedure should be followed.

2.0 PURPOSE

Raw data is edited for the following purposes:

- identify and delete gross errors that have resulted from equipment malfunction, power failures, maintenance, audits and calibration activities;
- delete data periods that are erroneous as a result of digital acquisition or communication malfunctions;
- determine consistency of data between different modes of data records (i.e., between digital and strip chart records);
- determine consistency of data with National Weather Service data or with customary diurnal effects; and
- analyze and apply any adjustments to raw data that are technically justified and supported by adequate documentation.

3.0 DOCUMENTATION

All editing actions taken must be documented with supporting reasons as required input to data validation (ENSR SOP 2990).

4.0 PROCEDURE

Any apparent instrument or data handling problems in the field should be communicated in writing to the appropriate field supervisor with a copy to the responsible program manager.

4.1 Historical Network

For those projects where-strip charts are the primary data retrieval system the following procedures must be followed:

- the strip charts must be marked for day changes (hour changes must also be marked in the event of non-timed chart paper or time problems)
- both ends of each chart must be identified as to network/site/parameter and inclusive dates and times.
- all periods of invalid data are to be marked off on the strip chart and reasons documented in a log (may be done in the field - see SOP 2630)
- all periods of suspect data are reclassified as either valid or invalid
- charts are then either submitted with appropriate forms to be digitized or are hand-digitized

4.2 Digital Network - Real Time Data Logger etc.

- 4.2.1** A hard copy print out for each parameter-month should be obtained. Field station logs and back-up strip charts (if applicable) should be obtained for review with print-out. Periods of invalid data are to be marked and reasons documented. Periods of suspect data are reclassified as either valid or invalid.

5.0 DATA CHECKING

- 5.1** At least two values from each parameter month shall be checked against the redundant system, to assure that the data are correct with respect to identification. Any ID errors found should be corrected. Reduced values must agree within $\pm 2\%$ of full scale and ($\pm 10^\circ$ on wind direction).
- 5.2** Where no redundant system exists, in addition to the check for complete and correct identification, at least 5% of the reduced values from each data month shall be

checked against the strip chart by a person different from the one who digitized the chart. Tolerance or agreement is the same as in 5.1.

- 5.3** If the tolerance is exceeded in either the above, the correct value shall be inserted into the data base and one additional pair shall be checked. If these values also disagree, the entire data month must be checked and revised as necessary. Otherwise, steps 5.1 and 5.2 are complete.

Data Validation of Air Quality and Meteorological Data**Date: January, 2007****Revision No: 4****Author: Vincent Scheetz****Discipline: Air Monitoring****1.0 Purpose and Applicability**

This procedure defines minimum standards for acceptance of air quality and meteorological data from continuous monitors. Acceptance criteria for high volume particulate samples are given in ENSR SOP 2629-201, Filter Processing Method for the Determination of Suspended PM₁₀ SSI Particulate Values.

For some projects more stringent validation criteria may be imposed by the Quality Assurance Project Plan (QAPP) or Contract. In such cases, the more stringent criteria supersede this SOP.

2.0 Minimum Standards for Acceptance of Continuous Air Quality Data**2.1 Back-up Documentation (must exist)**

- The Field Station Log for the period under review,
- A field data assessment record,
- A multipoint calibration or audit data sheet dated within three months of the period under review,
- Precision and Level 1 Span checks (at least two per month),
- Hard-copy raw data (e.g., strip charts and/or data logger printout),
- Documentation of siting and physical and electronic configuration for the site (e.g., Monitoring Plan).

If any of the above documentation is unavailable, the affected data shall be considered suspect and shall not be validated until further review and investigation demonstrates its validity.

2.2 Accuracy

In the absence of a specific accuracy limit imposed by the QAPP or other project-specific controlling document, the following applies:

Data are invalid* if: 1) Span $\Delta\%$ > $\pm 15\%$,
Or 2) Baseline > $\pm 3\%$ of full scale from designated

Exceptions

Data points > 100 ppb will not be discarded solely on the basis of the zero criterion;

Data points < 20 ppb will not be discarded solely on the basis of the span criterion;

Data deletions or other changes shall not be implemented solely on the basis of audits, precision checks or calibration tracking (Level II span checks).
Data decisions will be primarily based upon dynamic calibration checks of the analyzers.

2.3 Completeness

The absolute minimum portion of an hour that can represent a valid hourly average is 45 minutes. Minimum completeness criteria for other averaging periods are listed below:

<u>Averaging Period</u>	<u>Minimum</u>
1-hour	45 min
3-hour	3 valid hours
8-hour	6 valid hours
24-hour	18 valid hours

3.0 Minimum Standards for Acceptance of Meteorological Data

3.1 Back-up Documentation

- Calibration data sheet dated within 6 months of the period under review
- Field station log for period under review
- Documentation of siting and physical and electronic configuration of the site (e.g., Monitoring Plan)

If any of the above documentation is unavailable, the affected data shall be considered suspect and shall not be validated until further review and investigation demonstrates its validity.

3.2 Accuracy

In the absence of specific accuracy limits imposed by the QAPP or other project-specific controlling document, the following minimum accuracy limits apply:

*See exceptions.

<u>Parameter</u>	<u>Validation Limits</u>	<u>Instrument Accuracy Limits</u>
Wind Speed	±5 m.p.h.	±0.5 m.p.h.
Wind Direction	±20°	±5.0°
Vertical Wind Speed	±2.0 mph	±0.5 m.p.h.
Temperature	±3.0°C	±0.9°F
Temperature Difference	±0.3°C	±0.18°F
Solar Radiation	±10%	±5%

3.3 Completeness

The absolute minimum portion of an hour that can represent a valid hourly average is 45 minutes. Minimum completeness criteria for other averaging periods are listed below:

<u>Averaging Period</u>	<u>Minimum</u>
1-hour	30 min
3-hour	3 valid hours
8-hour	6 valid hours
24-hour	18 valid hours

**{P Field Calibration: Climatronics
Wind Speed System****Date: 3rd Qtr 2006****Revision No: 4****Author: Vincent Scheetz****Division: Air Quality Monitoring****1.0 PURPOSE AND APPLICABILITY**

This document specifies the procedures used in the field to calibrate or audit a Climatronics Wind Speed Sensor.

2.0 RESPONSIBILITIES**2.1 Field Technician**

2.1.1 It is the responsibility of the field technician to read and perform the calibration in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.

2.1.2 It is also the responsibility of the field technician to document the calibration in the field station log, on the strip chart recorder as well as on any data forms contained within this procedure.

2.2 Project Manager

2.2.1 It is the responsibility of the project manager or designee to ensure that the calibration is performed at the designated frequency and to ensure that all necessary equipment is available and properly certified.

2.2.2 It is the responsibility of the project manager or designee to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 REQUIRED MATERIAL

- Synchronous Motor or Anemometer Drive (optical coupler) 300-900 RPM
- Frequency Counter calibrated within the previous twelve months.
- Oscilloscope
- Digital Voltmeter calibrated within the previous twelve months
- Frequency Generator
- Torque Watch Gauge or Torque Wheel calibrated within the previous twelve months
- Climatronics Instruction Manual

4.0 METHOD

- 4.1** Fill out the heading on the Wind Speed Calibration form (Figure 1). Be sure to record the sensor serial number.
- 4.2** "DOWN" the appropriate channels of the data acquisition system (DAS) to isolate the calibration challenges from the ambient data base. Be sure to "UP" the channels following the calibration to resume collection of ambient data.
- 4.3** Inside the shelter, monitor the wind speed sensor output while the tower person rotates the wind speed hub at 0, 300 and 900 RPM. Record the DAS response, counter indication, waveform condition and translator output voltage, as "Initial".
- NOTE: Wind speed transmitters can be tested inside the shelter if tower testing is not possible by removing the sensor from the tower and connecting the wind sensor to the system at the base of the tower.
- 4.4** If any initial readings are out of tolerance (see Table 1), locate the defective component and replace or adjust. Perform zero and span checks using switches on the front of the circuit card. If necessary recalibrate the circuit card according to the specifications designated in the instrument manual. Record translator output voltage, recorder and DAS responses on the Wind Speed Calibration form (Figure 1).
- 4.5** Remove the sensor from the cross arm and perform bearing test.
- 4.5.1** Loosen the cup set screws and remove the cups. Attach the torque watch or torque wheel to the sensor using the adapter provided with the torque device.
- 4.5.2** Verify the starting torque of the sensor in both clockwise (CW) and counter-clockwise (CCW) directions. Verify the torque over the entire azimuth of the sensor. Record the maximum starting torque in the appropriate space on the Wind Speed Calibration form.
- 4.5.3** The sensor or bearings should be replaced if the starting torque is greater than or equal to 0.3 gm-cm.
- 4.6** After installing the new or recertified sensor repeat steps 4.3 - 4.4. Record the counter indication, waveform condition, translator output voltage, recorder response and DAS response as "Final".

5.0 QUALITY CONTROL

- 5.1** All calibration documentation must be reviewed by the project manager or designee for accuracy and completeness. Test equipment must be listed by manufacturer, S/N and calibration date.
- 5.2** System specifications and acceptance criteria are contained in Table 1.

6.0 DOCUMENTATION

- 6.1** One copy of the completed calibration data sheet should be retained at the site.
- 6.2** The strip chart record of the calibration should be annotated as to calibration start and end times, significant pen deflections and identification of the person(s) performing the calibration.
- 6.3** A record of the calibration should be entered in the station log.
- 6.4** Calibration stickers should be completed and applied to all calibrated instrumentation.

7.0 REFERENCES

Not applicable

Tolerances*

	0 RPM	300 RPM	900 RPM
Scope Indication	No Waveform	Clean Square Wave with 1.5 Amplitude	
Counter	0 Hz	150 ± 2 Hz	450 ± 5 Hz
Recorder	0.5 ± 0.15 MPH	16.3 ± 0.5 MPH	47.8 ± 0.5 MPH
Translator	0.1 ± 0.03 V	3.25 ± 0.1 V	9.56 ± 0.1 V
DAS	± 0.5 MPH	16.3 ± 1.30 MPH	47.8 ± 2.90 MPH
Bearing Test	≤ 0.3 gm-cm		
*Vinyl or heavy duty cups			



Wind Speed Calibration

3rd Quarter 2005

Network: _____	Site: _____	Level: _____
Sensor Manufacturer: _____		Model #: _____
Range: _____	to: _____ mph	to _____ volts
Technicians: _____		Date: _____

Initial System Checks

Sensor SN: _____ Props SN: _____

Motor Speed	Ideal	Ideal	Freq (Hz)	DAS mph	Volts	Tolerance (± 0.45 mph + 5%)

Bearing Test: _____ Cups _____ Replaced: _____

Final System Checks

Sensor SN: _____ Props SN: _____

Motor Speed	Ideal	Ideal	Freq (Hz)	DAS mph	Volts	Tolerance (± 0.447 mph +

Bearing Test: _____ Prop _____ Replaced: _____

Test Equipment

Instrument	Manufacturer	Model	Serial #	Cal Date

Signature: _____ Q.C. Review: _____

Tolerances*

	0 RPM	300 RPM	900 RPM
Scope Indication	No Waveform	Clean Square Wave With 1.5 V Amplitude	
Counter	0 Hz	$150 \pm 2\text{Hz}$	$450 \pm 5\text{Hz}$
Recorder	$0.5 \pm 0.15\text{ MPH}$	$16.3 \pm 0.5\text{ MPH}$	$47.8 \pm 0.5\text{ MPH}$
Translator	$0.1 \pm 0.03\text{ V}$	$3.25 \pm 0.1\text{V}$	$9.56 \pm 0.1\text{V}$
DAS	$\pm 0.5\text{ MPH}$	$16.3 \pm 1.30\text{ MPH}$	$47.8 \pm 2.90\text{ MPH}$
Bearing Test	$\leq 0.3\text{ gm-cm}$		
*Vinyl or heavy duty cups.			

**Field Calibration: Climatronics
Wind Direction System****Date: 3rd Qtr. 2006****Revision No: 3****Author: Vincent Scheetz****Division: Quality Assurance****1.0 PURPOSE AND APPLICABILITY**

This document specifies the procedures used in the field to calibrate or audit a Climatronics wind direction sensor.

2.0 RESPONSIBILITIES**2.1 Field Technician**

2.1.1 It is the responsibility of the field technician to read and perform the calibration in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.

2.1.2 It is also the responsibility of the field technician to document the calibration in the field station log, on the strip chart recorder as well as on any data forms contained within this procedure.

2.2 Project Manager

2.2.1 It is the responsibility of the project manager or designee to ensure that the calibration is performed at the designated frequency and to ensure that all necessary equipment is available and properly certified.

2.2.2 It is the responsibility of the project manager or designee to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 REQUIRED MATERIALS

- Digital Multimeter calibrated within the previous twelve months
- Torque Watch Gauge or Torque Wheel calibrated within the previous twelve months
- Theodolite/Transit or Compass
- Climatronics Instruction Manual

4.0 METHOD

- 4.1 Fill out the heading of the Wind Direction Calibration form (Figure 1). Be sure to record the sensor serial number.
- 4.2 "DOWN" the appropriate channels of the data acquisition system (DAS) to isolate the calibration challenges from the ambient data base. Be sure to "UP" the channels following the calibration to resume collection of ambient data.
- 4.3 Identify landmarks and their associated angles from the sensor on the data sheet. Two landmarks approximately 90° apart should be used. (See 4.12 or 4.13)
- 4.4 Point the vane to the first landmark and record the translator output, strip chart recorder response and data acquisition system (DAS) response on the Wind Direction Calibration form. Point the tail to the landmark and record as above. Repeat procedure for landmark #2.
- 4.5 Convert the translator output voltage to degrees using the following equation (assuming a translator output voltage of 10.0 volts):

$$\frac{\text{translator voltage} \times 540}{\text{degrees}} = 10 \quad (1)$$

- 4.6 If any of the responses in steps 4.4 and 4.5 vary by more than $\pm 5.0^\circ$ from the designated value, locate the detective component and replace or adjust. Perform zero and span checks using switches on the front of the circuit card. If necessary, recalibrate the circuit card to the specifications designated in the instrument manual.
- 4.7 Remove the vane and attach the torque watch gauge or torque wheel to the wind direction sensor using the adapter provided with the torque device. Verify the starting torque every 10° until the torque has been checked over the entire azimuth in both clockwise (CW) and counter-clockwise (CCW) directions. Record the maximum CW and CCW torques observed. The maximum allowable torque is 8.0 gm-cm.
- 4.6 Re-install the vane and rotate 2 revolutions CW and stop when system output reads approximately 510°. Then rotate the vane very slowly CW to 540°. The sensor should switch cleanly with the recorder displaying a continuous line from near 540° to near 180°. Rotate the vane CCW to approximately 30° and then very slowly to 0°. The sensor should switch cleanly, with the recorder trace continuous from near 0° to near 360°.
- 4.7 If maximum starting torque is less than 8.0 gm-cm and other checks are satisfactory, the same sensor may be reinstalled. When all components are in place, repeat steps 4.4 and 4.5 record the responses as "final".

Perform zero, span and span 540° checks and record in the appropriate spaces on the wind direction form.

- 4.8 The system is in calibration if all readings are within $\pm 5.0^\circ$ of the designated value.
- 4.9 Following calibration and re-installation of the sensor, establish the angle of the sensor cross-arm with the sensor boom extended in the normal data collection position. Place a permanent marker away from the tower (or use an established landmark) in direct line with the cross-arm. This marker can then be used to verify the proper alignment of the cross arm.

4.10 Landmark Coordinate Designation Using a Theodolite (Sun Method)

- 4.10.1 Prior to deployment to the field, use the software "Sundial" to produce a table of angles to the sun at various times of the day given Site latitude, longitude and the day on which the calibration is to be performed. An example of a printout can be found in Table 1.
- 4.10.2 Set the theodolite up at the base of the tower under the wind direction sensor.
- 4.10.3 At the exact 15 minute interval (to the second), site the sun in the cross-hairs of the theodolite and lock in the scale to the designated angle to the sun.
- 4.10.4 Once locked in, the theodolite can now be used to site landmarks. Angles to these landmarks are obtained by a direct read off the theodolite 0-360° graduated scale.

4.11 Landmark Coordinate Designation using a Compass (No-Sun Method)

- 4.11.1 Determine the correct magnetic declination factor to be used at the site from the USGS map (Figure 2). If the site deviation is 10° west, 10° must be subtracted from the compass reading to determine the true angle. The compass, in this case, reads 10° more than the true angle. If the site deviation is 10° east, 10° must be added to the compass reading to determine the true angle. The compass, in this case, reads 10° less than the true angle.

Example: To establish 270° with a magnetic declination correction of 10° west, the compass must read 280° for the true angle of 270°.

Example: To establish 270° with a magnetic declination correction of 10° east the compass must read 260° for the true angle of 270°.

- 4.11.2 Once the magnetic declination correction is determined, angles to landmarks can be obtained by sighting "in line" from tower to landmark and applying the declination correction. Be sure to stand in line between the tower and landmark but far enough away from the tower to alleviate any magnetic interference generated by the metal tower.
- 4.11.3 Because of the potential errors involved with using a compass to determine angles, such as magnetic interferences or misapplication of declination correction, it is recommended to verify the compass determined coordinates using the "Sun Method" when conditions are appropriate.

5.0 QUALITY CONTROL

- 5.1 All calibration documentation must be reviewed by the project manager or designee for accuracy and completeness. Test equipment must be listed by manufacturer, S/N and calibration date.
- 5.2 The maximum allowable system response deviation from the designated landmark coordinate is 5.0 degrees.
- 5.3 The maximum allowable starting torque for a wind direction sensor is 8.0 gm-cm.

6.0 DOCUMENTATION

- 6.1 One copy of the completed calibration data sheet should be retained at the site.
- 6.2 The strip chart record of the calibration should be annotated as to calibration start and end times, significant pen deflections and identification of the person(s) performing the calibration.
- 6.3 A record of the calibration should be entered in the station log.
- 6.4 Calibration stickers should be completed and applied to all calibrated instrumentation.

7.0 REFERENCES

Not applicable

FRIDAY 10 NOV 1989
 Longitude 71.1094
 Day of Year 314

LOCATION Haverhill Met Tower
 Latitude 42.7592
 Julian Day 2447841

SUN

Declination -17.27 degrees
 Rises 6:30 EST
 Transit Meridian 11:28:26:EST
 Civil Twilight Begins 6:1 EST

Distance 0.9901004 A.U.
 Sets 16:26 EST
 Ends 16:55 EST

Date	Time	Elevation	Azimuth
11/10/89	8:00	13.3	129.3
11/10/89	8:15	15.4	132.2
11/10/89	8:30	17.4	135.3
11/10/89	8:45	19.3	138.5
11/10/89	9:00	21.1	141.8
11/10/89	9:15	22.8	145.3
11/10/89	9:30	24.3	148.8
11/10/89	9:45	25.7	152.5
11/10/89	10:00	26.9	156.2
11/10/89	10:15	27.9	160.1
11/10/89	10:30	28.8	164.1
11/10/89	10:45	29.5	168.1
11/10/89	11:00	30.0	172.2
11/10/89	11:15	30.2	176.3
11/10/89	11:30	30.3	180.5
11/10/89	11:45	30.2	184.6
11/10/89	12:00	29.9	188.8
11/10/89	12:15	29.4	192.8
11/10/89	12:30	28.6	196.9
11/10/89	12:45	27.7	200.8
11/10/89	13:00	26.7	204.6
11/10/89	13:15	25.4	208.4
11/10/89	13:30	24.0	212.0
11/10/89	13:45	22.5	215.5
11/10/89	14:00	20.8	218.9
11/10/89	14:15	19.0	222.2
11/10/89	14:30	17.0	225.4
11/10/89	14:45	15.0	228.4
11/10/89	15:00	12.8	231.4
11/10/89	15:15	10.6	234.3
11/10/89	15:30	8.3	237.0
11/10/89	15:45	5.9	239.7
11/10/89	16:00	3.5	242.4
11/10/89	16:15	1.0	244.9
11/10/89	16:30	-1.6	247.4
11/10/89	16:45	-4.2	249.4

Table 1

Wind Direction

Calibration ☐ Audit ☐ Other ☐

Network: _____ Site: _____ Date: _____
 Sensor: _____ Model: _____ Range: _____ to _____ (°) _____ to _____ Volts
 DAS: _____ SN: _____ Time Off Line: _____ Time On Line: _____

Initial System Checks

Level: _____ SN: _____

Landmark	Angle	Translator		DAS	
	(°)	(volts)	(°)	(volts)	(°)
#1	To #1				
	From				
#2	To				
	From				
Torque: CW _____ CCW _____ (gm-cm)		Switching OK?		Vane Condition:	
Bearings Replaced? Yes <input type="checkbox"/> No <input type="checkbox"/>		Yes <input type="checkbox"/> No <input type="checkbox"/> N/A <input type="checkbox"/>		Vane Replaced? Yes <input type="checkbox"/> No <input type="checkbox"/>	

Final System Checks

Level: _____ SN: _____

Landmark	Angle	Translator		DAS	
	(°)	(volts)	(°)	(volts)	(°)
#1	To #1				
	From				
#2	To				
	From				

Circuit Card	Initial		Final	
	Translator (°)	DAS (°)	Translator (°)	DAS (°)
Zero				
Span				
540° (if applicable)				

Sensor Output Linearity Verification

Rose Dial	Response		Rose Dial	Response	
	Translator	DAS		Translator	DAS
0			210		
30			240		
60			270		
90			300		
120			330		
180			360		

Test Equipment

Instrument _____
 Make _____
 Model _____
 SN _____
 Cal Date _____

Signature: _____

QC Review: _____

Accepted ☐ Rejected ☐

Figure 1

Figure 2

SOP NUMBER: 2580-001

Ambient Monitoring Transfer Standard Flow Meter Calibration

Date: 3rd Qtr., 2006
Revision Number: 3
Author: Vincent Scheetz
Discipline: Air Measurements

1.0 PURPOSE AND APPLICABILITY

- 1.1** Flow meters may be calibrated by two different techniques: either against a primary/secondary standard or against a transfer standard. For this SOP, a bubble flow meter or spirometer are primary standards, a wet test meter is secondary standard, and a mass flow meter or dry gas meter are transfer standards. The procedures described herein apply to the calibration of a flow meter by any of the above techniques.
- 1.2** The standard conditions to which the flow meter is to be traceable must be determined before the flow meter is calibrated. This information can be found in the Project Monitoring or Quality Assurance Plan or can be received from the project manager. Typically, standard conditions are 25°C and 760 mmHg, however, individual project requirements may dictate alternate values.

2.0 RESPONSIBILITIES

2.1 Technician

- 2.1.1** It is the responsibility of the technician to read and perform the operation in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.
- 2.1.2** It is also the responsibility of the technician to document the procedure in the field station log as well as on any data forms contained or referred to within this procedure.

2.2 Laboratory Manager

- 2.2.1** It is the responsibility of the laboratory manager or designee to ensure that all necessary equipment is available and properly certified.
- 2.2.2** It is the responsibility of the laboratory manager or designee to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 SUPPORTING MATERIALS

- Bubble flow meter, Hastings Model No. HBM-1 with multiple tubes or equivalent
- Spirometer, Collins, or equivalent
- Wet test meter, Precision Scientific, or equivalent
- Mass flow meter, Hastings, or equivalent
- Stop watch, accurate to ± 0.001 min
- Thermometer, NIST-traceable, accurate to $\pm 0.1^\circ\text{C}$
- Clean air supply
- Metering valve
- In-line pressure gauge (optional)
- Laboratory barometer

4.0 METHOD

4.1 Calibration by Primary or Secondary Standard

- 4.1.1** Allow the flow meter to warm up for one hour prior to calibration.
- 4.1.2** Complete the heading information on the appropriate flow meter calibration form (Figures 1, 2, and 3). Note that "range" refers to the dynamic range of the reference instrument. For a bubble flow meter, the range must not exceed twice the maximum volume/minute. For a spirometer or wet test meter, the range must not exceed the manufacturer's specifications.
- 4.1.3** If the flow meter being calibrated is a component in a dynamic system, the entire system must be leak checked prior to initiation of calibration.
- 4.1.4** Figure 4 is a schematic diagram for the calibration of a flow meter using a bubble meter, spirometer, or a wet test meter. Any calibration configuration must be leak tested prior to use.
- 4.1.5** Calibrate the flow meter at a minimum of 6 points equally spaced over the dynamic range of the meter. Allow the flow meter to stabilize for a minimum of 5 minutes at each point before determining the flow.
- 4.1.6** Take a minimum of three readings at each point. Each of the three readings must be repeatable to $\pm 1\%$; if not, identify the problem, correct, and repeat readings.
- 4.1.7** Record the volume, elapsed time, temperature, barometric pressure correction factor and flowmeter voltage in the appropriate columns for each calibration point. When performing a rotameter calibration, note on all data sheets and calibration curves whether top or middle of ball was read.

4.2 Calculations

- 4.2.1** Calculate the flows for each data point in step 4.1.5 according to the following equations:

$$Q_{amb} = \frac{V}{t}$$

where

Q_{amb} is the flow at ambient conditions (cc or l/min);

V = the volume of air (cc or l/min);

t = the time (min).

- 4.2.2** Correct these values to STP. Determine standard conditions from the Project Monitoring or Quality Assurance Plan or from the project manager. Use the conversion factor (conv.) applicable to the particular standard conditions.

$$Q_{STP} = \frac{P_{amb} - P_{diff} - P_{H_2O}}{T_{amb}} \times (conv.) \times Q_{amb}$$

or

$$Q_{STP} = \text{Correction factor} \times Q_{amb}$$

where

Q_{STP} = flow (cc or l/min) corrected to standard conditions

P_{amb} = ambient pressure (mm Hg);

P_{diff} = differential pressure (mm Hg) (wet test meter only);

P_{H_2O} = water vapor pressure from Table 1, mm(Hg) (bubble meter only);

T_{amb} = ambient temperature, (°K); °K = °C + 273.15

Q_{amb} = flow rate at ambient conditions (cc or l/min); and

conv. = conversion factor to standard conditions

25°C and 760 mmHg = 0.3923

0°C and 760 mmHg = 0.3594

- 4.2.3** Calculate the average flow for each calibration point.

Note: Corrections for (P_{diff}) are factored only when a wet test meter is used as the standard. Corrections for (P_{H_2O}) are factored only when a bubble meter is used as the standard.

- 4.2.4** Perform a linear regression of the flow meter voltage and resulting flows. Designate the flow meter voltage "x" and resulting flow "y", producing an equation in the form:

$$y = M(x) + b$$

where

y = flow (cc or l/min)

x = flow meter voltage

m = slope

b = intercept

- 4.2.5** A flow meter calibration must have a correlation coefficient (r^2) value of 0.9998 or better.

- 4.2.6** Record the manufacturer, serial number and calibration date of all test equipment used during the calibration on the data sheet.

4.3 Calibration by Transfer Standard

- 4.3.1** Figure 5 is a schematic diagram for the calibration of a flow meter with a transfer standard. A transfer standard is a dry gas meter or mass flow meter that has previously been calibrated against a primary or secondary standard.
- 4.3.2** Repeat step 4.2.2, but only one reading is required for each calibration point.
- 4.3.3** Complete heading on the calibration form. In the appropriate columns, record the output voltage of reference flow meter and test flow meter reading (e.g., voltage for mass flow meter or ball height for rotameter).
- 4.3.4** Determine true flow rate (cc or l/min) from the linear regression equation for the reference flow meter.
- 4.3.5** Repeat step 4.2.4.
- 4.3.6** Record the manufacturer, serial number and calibration date of all test equipment used during the calibration on the data sheet.

5.0 QUALITY CONTROL

- 5.1 Immediately following calibration, the completed flow meter calibration form is to be submitted to the laboratory manager or designee for review. Flow calculations and correction factors are to be reviewed for accuracy. The conversion factors for standard conditions is to be verified. Standards are reviewed for traceability and the data sheet is reviewed for completeness.
- 5.2 A flow meter calibration must have a correlation coefficient (r^2) value of 0.9998 or greater for acceptance.

6.0 DOCUMENTATION

- 6.1 The completed and reviewed flow meter calibration form is to be distributed as follows:
- original to Quality Assurance
 - Copy to laboratory files
 - Copy remains with the flow meter.

7.0 REFERENCES

Not applicable

Table 1
P_{H2O}, Saturation Vapor Pressure Over Water (°C, mm Hg)
(Values for Fractional Degrees Between 50 and 89 Obtained by Interpolation)

Temp °C	0.0	0.2	0.4	0.6	0.8	Temp °C	0.0	0.2	0.4	0.6	0.8
-15	1.436	1.414	1.390	1.368	1.345	43	64.80	65.48	66.16	66.86	67.56
-14	1.560	1.534	1.511	1.485	1.460	44	68.26	68.97	69.69	70.41	71.14
-13	1.691	1.665	1.637	1.611	1.585	45	71.88	72.62	73.36	74.12	74.88
-12	1.834	1.804	1.776	1.748	1.720	46	75.65	76.43	77.21	78.00	78.80
-11	1.987	1.955	1.924	1.893	1.863	47	79.60	80.41	81.23	82.05	82.87
-10	2.149	2.116	2.084	2.050	2.018	48	83.71	84.56	85.42	86.28	87.14
-9	2.326	2.289	2.254	2.219	2.184	49	88.02	88.90	89.79	90.69	91.59
-8	2.514	2.475	2.437	2.399	2.362	50	92.51	93.5	94.4	95.3	96.3
-7	2.715	2.674	2.633	2.593	2.553	51	97.20	98.2	99.1	100.1	101.1
-6	2.931	2.887	2.843	2.800	2.757	52	102.09	103.1	104.1	105.1	106.2
-5	3.163	3.115	3.069	3.022	2.976	53	107.20	108.2	109.3	110.4	111.4
-4	3.410	3.359	3.309	3.259	3.211	54	112.51	113.6	114.7	115.8	116.9
-3	3.673	3.620	3.567	3.514	3.461	55	118.04	119.1	120.3	121.5	122.6
-2	3.956	3.898	3.841	3.785	3.730	56	123.80	125.0	126.2	127.4	128.6
-1	4.258	4.196	4.135	4.075	4.016	57	129.82	131.0	132.3	133.5	134.7
0	4.579	4.513	4.448	4.385	4.320	58	136.08	137.3	138.5	139.9	141.2
1	4.926	4.847	4.715	4.785	4.855	59	142.60	143.9	145.2	146.6	148.0
2	5.294	5.198	5.070	5.144	5.219	60	149.38	150.7	152.1	153.5	155.0
3	5.685	5.570	5.447	5.525	5.605	61	156.43	157.8	159.3	160.8	162.3
4	6.101	5.976	5.848	5.931	6.015	62	163.77	165.2	166.8	168.3	169.8
5	6.543	6.405	6.274	6.363	6.453	63	171.38	172.9	174.5	176.1	177.7
6	7.013	6.865	6.728	6.822	6.917	64	179.31	180.9	182.5	184.2	185.8
7	7.513	7.355	7.209	7.309	7.411	65	187.54	189.2	190.9	192.6	194.3
8	8.045	7.877	7.722	7.828	7.936	66	196.09	197.8	199.5	201.3	203.1
9	8.609	8.431	8.267	8.380	8.494	67	204.96	206.8	208.6	210.5	212.3
10	9.209	8.999	8.845	8.965	9.086	68	214.17	216.0	218.0	219.9	221.8
11	9.844	9.603	9.458	9.585	9.714	69	223.73	225.7	227.7	229.7	231.7
12	10.518	10.247	10.109	10.244	10.380	70	233.7	235.7	237.7	239.7	241.8
13	11.231	10.930	10.799	10.941	11.085	71	243.9	246.0	248.2	250.3	252.4
14	11.987	11.657	11.528	11.680	11.833	72	254.6	256.8	259.0	261.2	263.4
15	12.788	12.428	12.302	12.462	12.624	73	265.7	268.0	270.2	272.6	274.8
16	13.634	13.244	13.121	13.290	13.461	74	277.2	279.4	281.8	284.2	286.6
17	14.530	14.110	13.987	14.166	14.347	75	289.1	291.5	294.0	296.4	298.8
18	15.477	15.027	14.903	15.092	15.284	76	301.4	303.8	306.4	308.9	311.4
19	16.477	15.997	15.871	16.071	16.272	77	314.1	316.6	319.2	322.0	324.6
20	17.535	17.025	16.894	17.105	17.319	78	327.3	330.0	332.8	335.6	338.2
21	18.650	18.110	17.974	18.197	18.422	79	341.0	343.8	346.6	349.4	352.2
22	19.827	19.257	19.113	19.349	19.587	80	355.1	358.0	361.0	363.8	366.8
23	21.068	20.458	20.316	20.565	20.815	81	369.7	372.6	375.6	378.8	381.8
24	22.377	21.727	21.583	21.845	22.110	82	384.9	388.0	391.2	394.4	397.4
25	23.756	23.056	22.922	23.198	23.476	83	400.6	403.8	407.0	410.2	413.6
26	25.209	24.459	24.326	24.617	24.912	84	416.8	420.2	423.6	426.8	430.2
27	26.739	25.939	25.812	26.117	26.426	85	433.6	437.0	440.4	444.0	447.5
28	28.349	27.489	27.374	27.696	28.021	86	450.9	454.4	458.0	461.6	465.2
29	30.043	29.123	29.015	29.354	29.697	87	468.7	472.4	476.0	479.8	483.4
30	31.824	30.844	30.745	31.102	31.461	88	487.1	491.0	494.7	498.5	502.2
31	33.695	32.655	32.561	32.934	33.312	89	506.1	510.0	513.9	517.8	521.8
32	35.663	34.563	34.471	34.864	35.261	90	525.76	529.77	533.80	537.86	541.95
33	37.729	36.569	36.477	36.891	37.308	91	546.05	550.18	554.35	558.53	562.75
34	39.898	38.678	38.584	39.018	39.457	92	566.99	571.26	575.55	579.87	584.22
35	42.175	40.895	40.796	41.251	41.710	93	588.60	593.00	597.43	601.89	606.38
36	44.563	43.223	43.117	43.595	44.078	94	610.90	615.44	620.01	624.61	629.24
37	47.067	45.667	45.549	46.050	46.556	95	633.90	638.59	643.30	648.05	652.82
38	49.692	48.232	48.102	48.627	49.157	96	657.62	662.45	667.31	672.20	677.12
39	52.442	50.922	50.774	51.323	51.879	97	682.07	687.04	692.05	697.10	702.17
40	55.324	53.744	53.580	54.156	54.737	98	707.27	712.40	717.56	722.75	727.98
41	58.34	56.694	56.51	57.11	57.72	99	733.24	738.53	743.85	749.20	754.58
42	61.50	59.794	59.58	60.22	60.86	100	760.00	765.45	770.93	776.44	782.00
						101	787.57	793.18	798.82	804.50	810.21

Handbook of Chemistry and Physics, 45th Edition, Chemical Rubber Publishing Company, 1965

ENSR®

Date: _____ Technician: _____
Facility: _____ Calibration Gas: _____

Text Flow Meter	Test Flow Meter to be Used with the Following Instrument
Mfg _____	Mfg. _____
Model _____	Model _____
Type _____	Mfg S/N _____
Mfg S/N _____	ENSR S/N _____
ENSR S/N _____	
Reference Instrument:	
Mfg _____	
Model _____	
Mfg S/N _____	
ENSR S/N _____	
Range _____	

[illegible]

Figure 2

Flow Meter Calibration by Bubble Flow Meter	
Date:	Technician:
Facility:	Calibration Gas:
Test Flow Meter:	Test Flow Meter to be used with the Following Instrument:
MFG	MFG
Model	Model
MFG S/N	MFG S/N
ENSR S/N	ENSR S/N
Referenced Instrument:	
MFG	
Model	
MFG S/N	
ENSR S/N	
Range	

[illegible]

ENSR.

Date: Technician:
Facility: Calibration Gas:

Mfg _____
Model _____
Mfg S/N _____
ENSR S/N _____

Mfg. _____
Model _____
Mfg S/N _____
ENSR S/N _____

Mfg _____
Model _____
Mfg S/N _____
ENSR S/N _____
Range _____

[illegible]

Figure 4
Flowmeter Calibration with a Primary/Secondary Standard

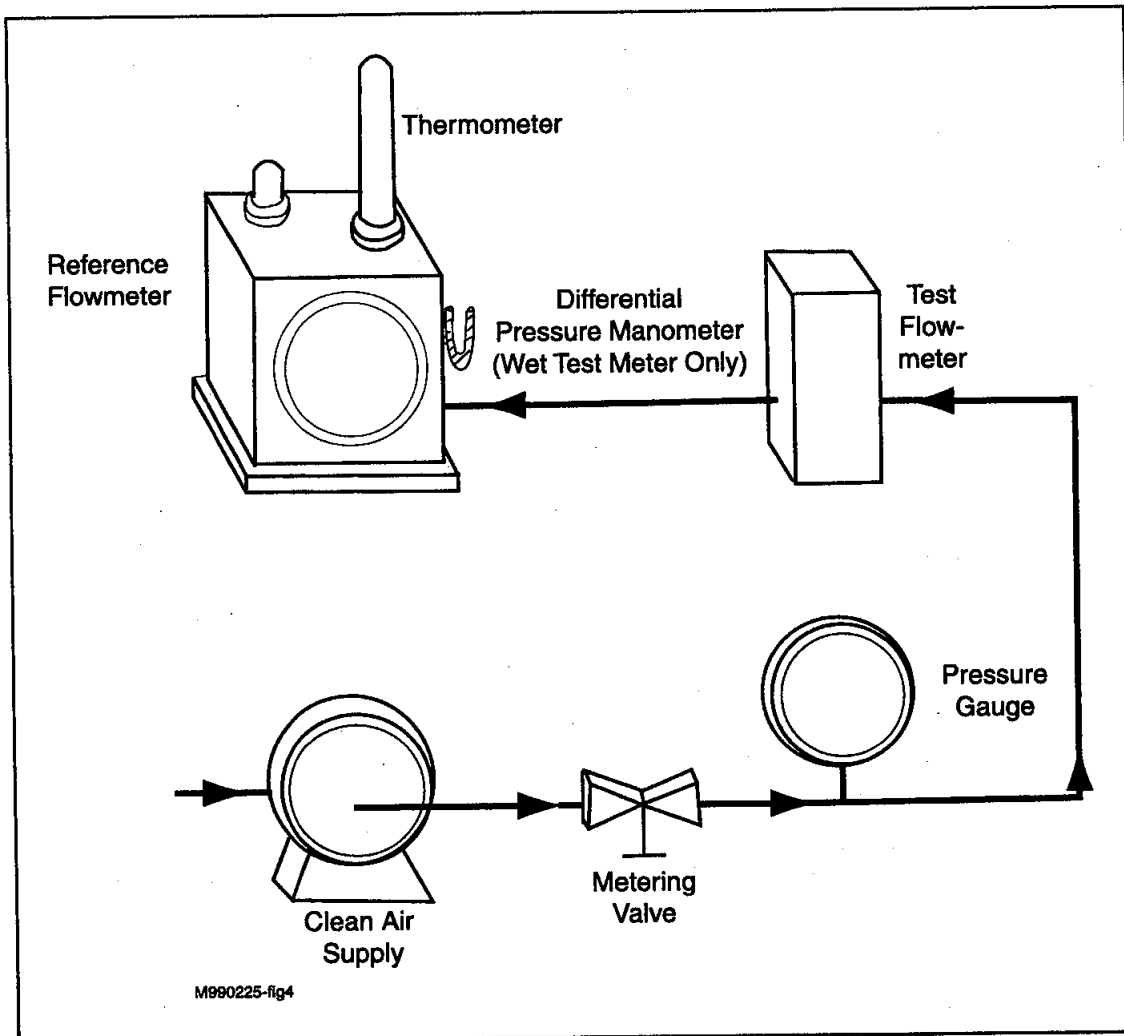
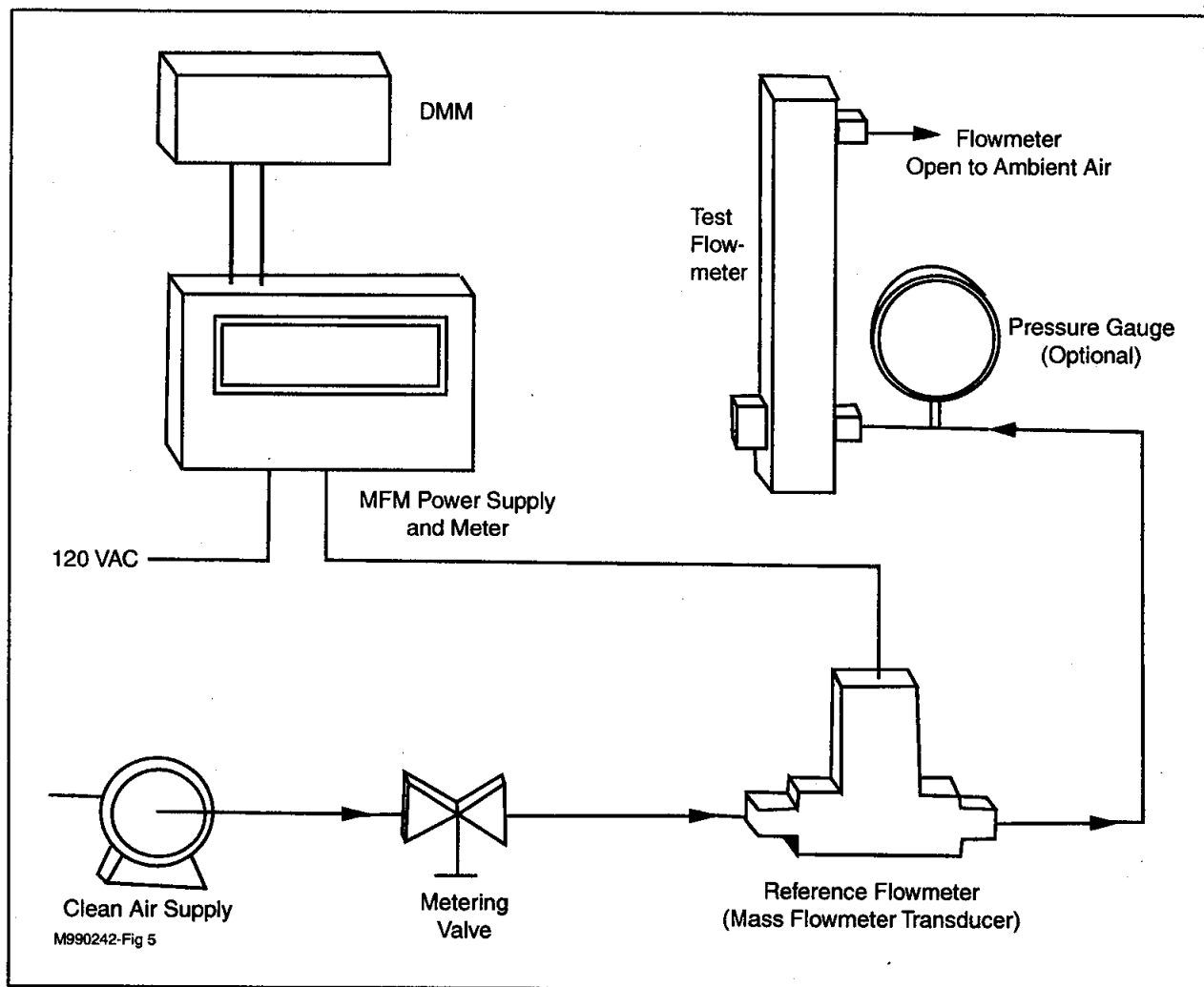


Figure 5
Flowmeter Calibration with Transfer Standard



SOP NUMBER: 2580-200**Operation and Calibration of the
API Model 700E Calibrator**

Date: 2006
Revision Number: 00
Author: Vincent Scheetz
Discipline: Air Measurements

1.0 APPLICABILITY

This standard operating procedure is to be used for the field use, operation, and calibration of the API 700E gas calibration system. This procedure conforms to the requirements of ENSR SOPs 2600, Field Calibration Control Plan and 2630, Routine Data Collection and Evaluation and applies to all individuals who are operating this calibration system according to USEPA guidelines. This standard operating procedure is to be used for calibrating the air and span flow controllers of the API Model 700E dilution calibration system, using the BIOS Model DryCal reference flow standard or other equivalent air flow measuring device. The API 700E meets or exceeds USEPA requirements for a Transfer Standard.

1.1 Flow Standard Calibration

The BIOS must have been certified within the past year.

2.0 RESPONSIBILITIES**2.1 Field Technician**

- 2.1.1** It is the responsibility of the field technician to read and perform the calibration in accordance with the methods and requirements specified in the API 700 E Operator's Manual, as well as this and all referenced ENSR Standard Operating Procedures.
- 2.1.2** It is also the responsibility of the field technician to document the calibration in the field station log and on data forms contained within this procedure.

2.2 Project Manager

- 2.2.1** It is the responsibility of the project manager or designee to ensure that the calibration is performed at the designated frequency and to ensure that all necessary equipment is available and properly certified.
- 2.2.2** It is the responsibility of the project manager or designee to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 REQUIRED MATERIALS

3.1 Equipment required:

- BIOS with a module that covers the range of 0-100 sccm and a module that covers the range of 0-10 slpm.
- Barometer and thermometer
- Thermo 700E spreadsheet form
- Open end wrench 9/16"
- 1/4" Teflon tubing/paristolic tubing
- Gas cylinder, with associated certification documentation
- Pressure regulator for gas cylinder

3.2 Documents

ENSR SOP 2400, Traceability of Standards

Operator's Manual for Teledyne API Model 700E Multigas Calibration System

4.0 METHOD

4.1 Gas Connection

4.1.1 Connect Calibration gases to the API 700 by following instructions in Section 3.2.4 of the Operator's Manual.

4.1.2 Read and Follow instructions in Section 3.2.5 of the Operator's Manual to connect the gas sample manifold.

4.1.3 When using the O3 generator options of the 700 E, connect additional supply lines in accord with Section 3.2.6 of the Operator's Manual.

4.2 Operation Instructions

4.2.1 Power - Turns the AC power on.

4.2.2 The M700E dynamic dilution calibrator requires a minimum of 30 minutes for all of its internal components to reach a stable operating temperature.

- Perform a functional check according to Section 3. 2.10 of the Operator's Manual.

4.2.3 The M700E Dynamic Dilution Calibrator generates calibration gases of various concentrations by precisely mixing component gases of known concentrations with diluent (zero air). When the instrument is equipped with the optional O₃ generator and photometer, it can also use the gas phase titration method for generating very precise concentrations of NO₂. In either case, it is necessary to program the concentrations of the component gases being used into the M700E memory.

4.3 Start-up and Operation

Start-up and Operation of the 700E is described in Section 6.0 of the Operator's Manual. Tests and operating modes available should be studied carefully and the operator is directed to follow procedures outlined in Section 6.

4.4 Calibration

Basic electronic calibration of the M700E Dynamic Dilution Calibrator is performed at the factory. Normally there is no need to perform this factory calibration in the field; however, the performance of several of the instruments key subsystems should be verified periodically and if necessary adjusted. These subsystems are:

- **Mass Flow Controllers:** The accuracy of the mass flow controller outputs is intrinsic to achieving the correct calibration mixture concentrations, therefore the accuracy of their output should be checked and if necessary adjusted every 6 months (see Sections 8.1 and 8.2 of the Operator's Manual).
- **O₃ Photometer:** If your M700E is equipped with the optional O₃ photometer its performance should be periodically verified against an external transfer standard (see Section 8.3 of the Operator's Manual).
- **O₃ Generator:** If your M700E is equipped with the optional O₃ generator, it should be periodically calibrated (see Section 8.4 of the Operator's Manual).

Documentation

Make certain that all data are included on the calibration form and that the activities are documented in the field station log book.

4.5 Standby

The line power to the Model 700E should not be turned off. To put the system into standby mode make sure no gas mode controls are active and disengage the ozone on/off control.

4.6 Loss of Power

If a power failure occurs, the Model 700E will turn on upon resumption of power.

4.7 Remote Operation

Remote operation of the Model 700E is similar to the manual operation. All mode commands that can be performed manually can be performed remotely, if the remote device has the capability and is connected as described above.

4.8 Computation of concentrations

The spreadsheet will calculate the necessary flow and setting using the formulas below:

$$\text{Gas flow} = \frac{\text{Input} \times \text{dilution flow}}{\text{Cylinder Concentration} - \text{Input}}$$

$$\text{Gas flow set} = \frac{\text{Gas flow} - b}{m}$$

5.0 QUALITY CONTROL

As soon as possible following calibration, the complete calibration form is to be submitted to the project manager or designee for review. Calibrator set points and dilution calculations are to be reviewed for accuracy. Standards are to be reviewed for traceability and completeness. DAS readings are to be reviewed for agreement and completeness.

6.0 DOCUMENTATION

- 6.1** A copy of the completed calibration forms including flow and settings are to be left in the shelter.
- 6.2** Note the occurrence of calibration tasks in the Field Station Log

7.0 REFERENCES

API Instruments Inc. Model 700E Multigas Calibration System Instruction Manual.

Spreadsheets (Example)

Station SIV
 API 700E Flow Calibrations
 2/5/05

	TANK	
	JAO1550	
NO	30.00	ppm
SO2	29.89	ppm

AIR

M=	987.24	B=	43.42	CORR=	0.999991
----	--------	----	-------	-------	----------

GAS

M=	0.9598	B=	2.157	CORR=	0.999995
----	--------	----	-------	-------	----------

FLOWS AND SETTINGS

INPUT	DILUTION FLOW CC/MIN	DILUTION SET	GAS FLOW CC/MIN	GAS SET
0.450	5000	5.02	76.14	77.1
0.200	5000	5.02	33.56	32.7
0.080	6000	6.03	16.04	14.5

INPUTS	
NO	SO2
.450	0.448
.200	0.199
.080	0.080

$\text{GAS FLOW} = (\text{INPUT} * \text{DIL FLOW}) / (\text{TANK CONC.} - \text{INPUT})$
 $\text{FLOW SET} = (\text{FLOW} - \text{B}) / \text{M}$

SOP NUMBER: 2580-200
API 700E BIOS FLOW CALIBRATIONS

SITE:	SIV	DATE:	2/5/2005	SN:	27733-229
FLOW STANDARD:	BIOS	MODEL:	DC-1 Rev. E, 6/1/05	SN 426	CERT.DATE 12/12/05
			DC-1SC Rev E,	SN 809	
PRESS:	762	MM/HG.		TEMP:	290.0
				DEG/K	
CORR. FAC. (QA TO QSTD = 298/760 * PATA) =				1.0300	

AIR FLOW METER
GAS FLOW METER

Y				X			
FLOW	FLOW	DISPLAY		FLOW	FLOW	DISPLAY	
ACCM	STD/CCM	(AIR)	VOLTS	ACCM	STD/CCM	(GAS)	VOLTS
1914	1971	1.96	0.201	15.5	16.0	14.50	0.152
3857	3973	3.97	0.398	34.5	35.5	34.70	0.349
4824	4969	4.98	0.496	43.9	45.2	44.80	0.447
5761	5934	5.98	0.595	53.3	54.9	54.90	0.546
6734	6936	6.98	0.693	72.2	74.4	75.20	0.743
7700	7931	7.99	0.789	81.3	83.7	85.10	0.834
M= 987.24				M= 0.9598			
B= 43.42				B= 2.157			
CORR= 0.999991				CORR= 0.999995			

SOP NUMBER: 2600-101

Calibration Check or Audit Using a TECO 49 Ozone Transfer Standard

Date: 2nd Qtr. 1993

Revision Number: 1

Author: Tony Sacco

Discipline: Air Toxics Measurements

1.0 PURPOSE AND APPLICABILITY

This document describes the procedures used to perform a field calibration check or audit of an ozone analyzer using a TECO 49 as a calibration standard and fulfill the requirements of ENSR SOP 2600, Field Calibration Control Plan.

2.0 RESPONSIBILITIES

2.1 Field Technician

- 2.1.1** It is the responsibility of the field technician to read and perform the calibration in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.
- 2.1.2** It is also the responsibility of the field technician to document the calibration in the field station log, on the strip chart recorder as well as on any data forms contained within this procedure.

2.2 Project Manager

- 2.2.1** It is the responsibility of the project manager or designee to ensure that the calibration is performed at the designated frequency and to ensure that all necessary equipment is available and properly certified.
- 2.2.2** It is the responsibility of the project manager or designee to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 REQUIRED MATERIALS

- Reference TECO 49, certified as a transfer standard, within the previous three months with current certification data.
- Air supply pump with fresh charcoal column and particulate filter.
- Approximately four feet of 1/4" teflon tubing for air supply
- Approximately four feet of 1/4" teflon tubing vented to atmosphere using a fluoroware tee. This tubing should be "seasoned" to ozone.
- Digital Voltmeter (DVM) calibrated within the previous twelve months

- O₃-UV Photometer form (Figure 1)
- ENSR SOP 2600, Field Calibration Control Plan
- ENSR SOP 2901-001, Documentation of Field Calibration of Air Quality Instrumentation

4.0 METHOD

4.1 Set-Up

- 4.1.1** Set the reference TECO 49 on a table or other level surface and attach power cord to the rear of the analyzer and to power outlet. Attach a particulate filter to the sample port. Remove the protective caps from the exhaust, clean air, ozone and vent ports. Turn power switch on.
- 4.1.2** Set up the pump, charcoal column, and particulate filter so that air from the pump travels first through the charcoal, and then through the filter. Attach the air supply line to the port labeled "ZERO AIR" in the center of the rear panel. Do not turn the pump on.
- 4.1.3** Open the front panel door which will expose the zero/span controls of the TECO 49. Set the left hand toggle switch to "sample" and the right hand three position toggle switch to the center "ZERO" position.
- 4.1.4** From this point, the ideal situation would be to allow the TECO 49 to warm-up overnight. If this is not possible the reference TECO 49 will require at least one hour to warm-up.
- 4.1.5** Refer to Section III of the TECO 49 manual for the functions related to the front panel test buttons. Verify the proper operation of the analyzer by observing the Test A, Test B, Test P/T, Test Noise and Test A/B displays.
- 4.1.6** Depress the "Run PPB" and "P/T ON" front panel buttons. Ensure that the "Remote" button is NOT engaged.
- 4.1.7** After the warm-up, set the left hand toggle switch to "SPAN/ZERO" and turn on the clean air pump and allow the reading in the display window to stabilize. This is the zero-offset. Review the certification documentation for the reference TECO 49. Verify that the observed zero offset is within 4 ppb of the zero offset documented in the reference TECO 49 certification (y-intercept in linear regression). If it is not, the zero air supply may be contaminated or the reference TECO 49 may require more warm-up time.
- 4.1.8** The flow through the ozonator is controlled by regulating the pressure through a glass capillary (gold). There must be sufficient air flow to

accommodate the reference TECO 49 (1-3 SLPM), the analyzer under test and an excess of at least 1 SLPM at the "VENT" port. Flow is adjusted by the pressure regulator located inside the TECO 49 (higher pressure increases flow). If there is some concern as to whether or not flow is adequate, connect a rotameter to the "VENT" port when flow is being supplied to both the reference TECO 49 and the test analyzer to verify positive pressure.

4.2 Calibration Check/Audit

- 4.2.1 Reconfigure the digital data acquisition system (DAS) such that the audit challenges are excluded from the valid ambient data base. Label the strip chart with date, local standard time, initials, employee # and "start audit" or "start calibration check". Note all activities in the Field Station Log.
- 4.2.2 Attach a 1/4" teflon line from the "OZONE" port on the rear panel of the reference TECO 49 to the sample port of the test analyzer. This line should be the same one used to connect the test analyzer to the sample distribution manifold with the sample line filter (if one is used) kept in the system. Connect a 1/4" line from the "VENT" port of the reference TECO 49 to the exhaust manifold of the shelter (or other suitable shelter exhaust). The analyzer is now receiving zero air from the reference TECO 49. Leave the analyzer in sample (operate) mode throughout the calibration/audit.
- 4.2.3 Once the analyzer under test has leveled off and is giving a stable response to zero air as indicated by two consecutive five minute averages from the DAS which agree within 1 or 2 ppb and/or a straight line on the strip chart, take five consecutive readings from the reference TECO 49 and record them on the data form in the column designated as "display". Average the five readings and enter this value in the "Average" column. Using the certification data, calculate the true input ozone concentration from the average display.
- 4.2.4 Record the analyzer reading as indicated on the DAS, in volts (DVM) if there is no digital DAS and strip chart percent (%) full scale. Mark the strip chart to indicate true input concentration and analyzer response.
- 4.2.5 Set the reference analyzer "Ozone Level" toggle switch to the A position and adjust the "set Level A" potentiometer for an ozone concentration of 0.350 - 0.450 ppm.

NOTE: The actual O₃ level (ppm) is determined from the certification data for the reference Photometer. This certification package will contain an equation for determining true ozone concentration from the display reading.

- 4.2.6** Once the analyzer is giving a stable response to this O₃ level, as indicated by two consecutive five minute averages from the DAS which agree within 1 or 2 ppb and/or a straight line on the strip chart. Take five consecutive readings from the reference TECO 49 display, and record them under "Display". Average these readings and record the result under "Average." Using the certification data, calculate the true input ozone concentration from the average display reading. Now enter the corrected reading under Corrected O₃ input (ppm).
- 4.2.7** Take the analyzer reading as indicated on the DAS, in volts (DVM) if there is no digital DAS and strip chart percent (%) full scale. Mark the strip chart to indicate true input concentration and analyzer response.
- 4.2.8** Repeat steps 4.2.5 - 4.2.7 for 0.150 - 0.200 ppm and 0.030 - 0.080 ppm.
- 4.2.9** If the percent difference ($\Delta\%$) between the analyzer output and the input O₃ concentration is less than 5.0% at all points, the analyzer is in calibration and no further action is required.
- 4.2.10** Set the "Ozone Level" toggle switch to the "ZERO" position. Take 5 consecutive readings from the reference TECO 49 and average them. Enter the average on the form under "Display". Verify that the zero has not changed by more than 3 ppb. If the zero has changed, the reference TECO 49 had not been properly warmed up when the first reading was taken, and steps 4.2.5 through 4.2.8 should be repeated.
- 4.2.11** Disconnect the sample line from the reference TECO 49 and reconnect it to the sample manifold. Be sure the line protrudes into the middle of the manifold and that the compression nut is tight.
- 4.2.12** Reconfigure the DAS to begin collecting valid ambient data. Mark the strip chart "end audit" or "end calibration check", mark initials, employee #, end time and date. Note results in station log and leave a completed copy of the data sheet at the site.

4.3 Troubleshooting (Calibration Check Only)

- 4.3.1** If the analyzer is a Dasibi and the percent difference at any point is greater than 5.0%, perform the following checks:

4.3.2 System Leak Check - Remove the sample line from the rear fitting and seal the opening with your finger. The sample flow, as indicated on the sample rotameter should drop to zero. If it does not, there is a leak in the system which must be repaired. Then return the sample line to the sample port.

4.3.3 Solenoid Valve Leak Test - The system leak check will not detect leaks across the solenoid valve. To check for leaks in the valve, remove the sample line from sample inlet connector and then remove the scrubber. Block the fitting on the side of the solenoid where the scrubber was connected with your finger. The flow on the rotameter should drop to zero for 1/2 of the measurement cycle and return to its original flow for the other half.

Now block the tee on the other side of the solenoid where the other side of the scrubber was connected and at the same time block the sample inlet connector. Again the flow should drop to zero for 1/2 cycle. If the flow does not drop all the way to zero, there is a leak across the solenoid and it should be replaced.

Return the scrubber to its position and reconnect the sample inlet to the valve. Then repeat step 4.3.3 to make sure that no leaks were caused during this test.

4.4 If the analyzer is a TECO 49 and the percent difference at any point is greater than 10%, perform the following checks:

4.4.1 External Leaks

In order to test for the presence of leaks two leak checks must be performed. For the first leak check, cap the sample port and flip the left hand toggle switch to the "sample" position. Cycle the "P/T" button until pressure is indicated on the LED display. The pressure should drop to approximately 150 mmHg if there are no leaks. If the pump diaphragm is in good condition and the capillary is not blocked, it should take less than 20 seconds for the pressure to drop to approximately 150 mmHg. The second leak check is performed by capping the zero air port, the ozone port and the vent port. The left hand toggle switch should then be flipped into the "Zero/Span" position. The pressure as indicated on the LED display should drop to approximately 150 mmHg.

If leaks are indicated by the leak check, they can best be detected by carefully tightening each fitting until the leak is found. A gross leak can often be heard as a "hissing" sound. A weak pump diaphragm should be

replaced (Section VIII-E of the manual). A clogged capillary should be cleaned or replaced (see Section VIII-5 of the manual).

4.4.2 Leaks Across the Solenoid Valve

Leaks across the solenoid valve can be caused by cold-flowing of the Teflon across the seat, or by particulates on the seat.

In order to check for leaks through the solenoid, generate an ozone concentration greater than 1/2 ppm and energize tests A/B pushbutton. This will display the concentration as determined in each cell individually. If the TECO 49 has stabilized, the average of ten successive simultaneous readings should agree to within three ($\pm 3\%$) percent. A constant low reading from one cell indicates an imbalance. The imbalance can be caused either by one cell or lines to that cell being extremely dirty or by a leaky valve. If cleaning the cells and lines does not correct the imbalance, a leaky valve is indicated.

4.4.3 If it is determined that leaks and scrubber efficiency are not the cause of the calibration check failure, then it is likely that ozone is being consumed by foreign matter either in the sample line or in the analyzer itself.

Thoroughly inspect all plumbing for dirt. Clean the optics according to Section V of the manual. If spare 1/4" tubing is available replace the sample line. If you haven't already changed the particulate filter element, do so now.

Make sure the system is leak-free and repeat the calibration check at the concentration that showed the largest $\Delta\%$ in the original calibration check. If it is now within tolerance, repeat the other points, and if they are all within tolerance, enter the readings on the data form. If the TECO 49 is still not within specifications, consult your supervisor for corrective action.

4.4.4 Converter Efficiency Check - If you have a spare scrubber, try exchanging it with the scrubber in the instrument, and repeat the calibration check at a high concentration.

4.5 In the case of ozone analyzers other than UV photometers, exceedance of $\pm 10\%$ requires that the analyzer be recalibrated. Refer to analyzer-specific procedures.

5.0 QUALITY CONTROL

- 5.1 All calibration documentation must be reviewed by the project manager or designee for accuracy and completeness. Test equipment must be listed by manufacturer, S/N and calibration date.
- 5.2 The maximum allowable system response deviation from the designated input is $\pm 10.0\%$, however, a multipoint calibration should always leave the analyzer operating within $\pm 5.0\%$ of the designated input.

6.0 DOCUMENTATION

- 6.1 One copy of the completed calibration data sheet should be retained at the site.
- 6.2 The strip chart record of the calibration should be annotated as to calibration start and end times, significant pen deflections and identification of the person(s) performing the calibration.
- 6.3 A record of the calibration should be entered in the station log.
- 6.4 Calibration stickers should be completed and applied to all calibrated instrumentation.

7.0 REFERENCES

Not applicable

Figure 1
Completed O₃ - UV Photometer Calibration Form

O₃ - UV Photometer Calibration

Network: ENSR Site: ACTS Instrument: TECO 44 S/N: 49-0126-73 Date: 5/11/93
 DAS: DESSA 2501-2500 S/N: 1623716 Strip Chart: E/A Time Off: 06:00 Time On: 07:00
 Calibration Standard: TECO 4412 S/N: 49-1145-146 Cal Date: 5/17/93 Cal Equation: $O_3 \text{ ppm} = (0.9163) * [\text{Ind. } O_3 \text{ conc.} - (0.0001)]$

Instrument Settings		Function Checks		Reason	
Initial: Zero Pot <u>51</u>	Span Pot <u>500</u>	Control Frequency A: <u>48.722</u>	B: <u>96.515</u>	Precision and Level One Check <input type="checkbox"/>	
Final: Zero Pot <u>51</u>	Span Pot <u>500</u>	Noise: A: <u>0.942</u>	B: <u>1.143</u>	Multipoint Calibration <input type="checkbox"/>	
		Pressure: <u>758</u> (mmHg)	Temperature: <u>28.0</u> C	Other <u>Auto</u>	<input checked="" type="checkbox"/>

Calibrator Input		Analyzer Response		
O ₃ Setting	Display	Average (ppm)	Corrected O ₃ Input (ppm)	DAS (Vdc)
0.000	0.000 0.001 0.000	0.001	0.001	0.002 0.002 0.001
0.450	0.450 0.448 0.450	0.449	0.447	0.890 0.894 0.892
0.175	0.174 0.175 0.173	0.174	0.173	0.344 0.344 0.345
0.075	0.075 0.076 0.074	0.075	0.075	0.150 0.150 0.144
				0.150 0.150
				Average Δ %
				-0.07%

Standards Comparison

Calibration Standard		Network Standard	
Setpoint	Display	Corrected Average	Display
0.450	0.450 0.449 0.449	0.447	0.447 0.448 0.448
0.075	0.075 0.074 0.074	0.074	0.073 0.073 0.073
	Average: 0.449		Average: 0.446
	Average: 0.074		Average: 0.073
			Average: 0.073
Network Standard: <u>TECO 44 TS</u> S/N: <u>49-25307-213</u> Cal Date: <u>4/26/93</u>		Cal Equation: $O_3 \text{ ppm} = (1.0025) * [\text{Ind. } O_3 \text{ conc.} - (0.0003)]$	

In-Station Ozonator Check

Setpoint (Pot)	DAS Response (Vdc)	DAS Average (Vdc)(ppm)

Signature: Paula DeBachinskiQC Review: Donald WhiteAccepted ☒ Rejected ☐

SOP NO: 2600-137

ENSR Consulting and Engineering

**Installation, Calibration and
Operation of the Thermo Electron
Model 42i Oxides of Nitrogen
Analyzer**

Date: 4th Quarter 2006

Revision No: 0

Author: Vincent Scheetz

1.0 PURPOSE AND APPLICABILITY

This procedure is to be followed for the installation, calibration and operation of the Thermo Environmental (Thermo) 42i Oxides of Nitrogen Analyzer. It conforms to the requirements of ENSR SOPs 2600, Field Calibration Control Plan and 2630, Routine Data Collection and Evaluation.

This instrument is an EPA Reference Analyzer only when it is operated under the following conditions:

- Range: 0 - 0.5 ppm
- Temperature: 20 - 30°C
- Power: 105 - 125 VAC

2.0 RESPONSIBILITIES

2.1 Field Technician

2.1.1 It is the responsibility of the field technician to read and conduct the operation in accordance with the methods and requirements specified in this and all referenced ENSR Standard Procedures.

2.1.2 It is also the responsibility of the field technician to document the procedure in the field station log, strip chart recorders and on any data forms contained within this procedure.

2.2 Project Manager

2.2.1 It is the responsibility of the project manager or designee to ensure that the operation is performed at the designated frequency and to ensure that all necessary equipment is available and properly certified.

2.2.2 It is also the responsibility of the project manager or designee to ensure that all generated documentation is reviewed for accuracy, completeness and adherence to this procedure and is reviewed in a timely manner so as to avoid needless data loss should an error be discovered.

3.0 REQUIRED MATERIALS

- Instruction Manual Thermo 42i
- ENSR SOP 2600, Field Calibration Control Plan
- ENSR SOP 2600-700, Operation of the ENSR Portable Field Calibration System
- ENSR SOP 2630, Routine Data Collection and Evaluation.
- Digital volt meter (Fluke 8020A or equivalent), calibrated within the previous twelve months
- Gas Dilution/Gas Phase Titration Calibration system which has been calibrated within the previous three months
- Clean Air Unit capable of generating 10 liters/minute of clean, dry air at 20 psi. This clean air must contain less than 0.001 ppm of NO₂ and O₃. A cylinder of pressurized Z-1 air may be used in place of the clean air unit.
- Calibration gas NO in N₂ (30 - 50 ppm with less than 1.0 ppm NO₂) certified traceable to NIST SRM using EPA Protocol 2. The calibration gas must have been certified within the previous 24 months.
- Gas regulator CGA 660
- Leak tester capable of supplying a negative pressure of at least 22" Hg

4.0 METHOD

4.1 Installation

Refer to Chapter 2 of the Thermo 42i manual for unpacking instructions.

4.1.1 Components which should accompany a complete analyzer includes:

- Thermo 42i analyzer
- Instruction Manual
- Instrument power cord
- Reaction chamber pump
- Flow accumulator with fittings

- Ozone scrubber with fittings
- Air dryer and filter
- Interconnect cable
- Signal cable (BNC connector)
- Photomultiplier high voltage cable (SHV connector)
- Accessory box:

(2) 1 meter lengths Teflon tubing with nuts and ferrules

(1) 2 meter lengths Teflon tubing with nuts and ferrules

(1) 0.05 meter length stainless steel tubing with nut at one end

WARNING The Model 42i is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated.

4.1.2 Connect the sample line to the SAMPLE bulkhead on the rear panel (Figure 4-1). Ensure that the sample line is not contaminated by dirty, wet, or incompatible materials. All tubing should be constructed of FEP Teflon®, 316 stainless steel, borosilicate glass, or similar tubing with an OD of 1/4-inch and a minimum ID of 1/8-inch. The length of the tubing should be less than 10 feet.

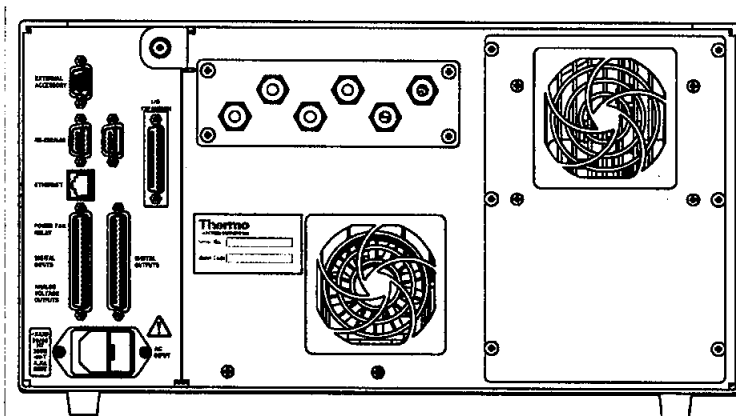


Figure 4-1. Model 42i Rear Panel

Note Gas must be delivered to the instrument at atmospheric pressure. It may be necessary to use an atmospheric bypass plumbing arrangement as shown in Figure 2-4 of the manual.

4.1.3 Connect the air dryer to the DRY AIR bulkhead.

4.1.4 Connect the EXHAUST bulkhead to a suitable vent or ozone scrubber. Verify that there is no restriction in this line.

4.1.5 Connect a suitable recording device to the rear panel connector. See the "Operation" chapter of the 42i manual for more information about the rear panel pin-outs.

CAUTION: IF THE CONNECTION IS DIFFICULT, YOU MAY BE INSTALLING THE WRONG CABLE.

4.1.6 Plug the instrument into an outlet of the appropriate voltage and frequency.

4.2 Leak Checking

Leaks in the pneumatics of the Thermo 42i instrument account for a major portion of its service problems. Consequently, it is essential to know how to troubleshoot the instrument for leaks.

A leak check device is required which can generate a negative pressure of 22 inches of mercury (Hg). It may be a very simple device consisting of a pump, shutoff valve and gauge.

4.2.1 The unit is considered to be leak tight if it loses no more than 1 inch of Hg in one minute.

4.3 Start-up

4.3.1 Follow the OPERATION instructions as described in Section II of the instruction manual. The ideal situation would be to allow the analyzer to warm up overnight. If this is not possible, then allow the analyzer to warm up least 90 minutes prior to performing a start-up calibration and subsequent measurements.

Following the leak check and electronic adjustment, the Thermo 42i must be calibrated prior to collection of any data.

4.4 Calibration

4.4.1 Perform any maintenance and/or repair of the analyzer described in the Thermo 42i manual including a pneumatic leak check and electronic adjustment prior to starting calibration.

4.4.2 Complete the heading section of the Gas Dilution Calibration Form. Record instrument identification numbers, site information, and all other pertinent heading information.

4.4.3 Purge the NO gas pressure control regulator and connect the calibration system for use as described in ENSR SOP 2600-700, Operation of the ENSR Portable Field Calibration System.

CAUTION: OPERATION OF THIS SYSTEM WITHOUT PROPER PURGING OF THE REGULATOR WILL RESULT IN AN ERRONEOUS CALIBRATION.

4.4.4 Analyzer Readings

In all cases analyzer readings should be taken as follows:

From the DAS. System responses should be retrieved and recorded as five minute average readings. If five minute average readings are not available, DAS instantaneous voltage readings are to be retrieved, converted to ppm, and recorded once a stable response is observed. A response is considered stable when there has not been more than a 1.0% change over five minutes. DAS readings are used to determine system response and percent difference.

With a DVM, connected to the appropriate analog output leads on the analyzer.

4.4.5 The sample rate of the Thermo 42i is 700 +/- 200 cc/min. A minimum of 1500 cc/min air flow is required to satisfy the analyzer requirement. Additionally, since gas phase titration is required for a multipoint calibration of the analyzer, it is recommended that all titration points be generated at 5000 cc/min dilution air.

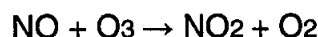
4.4.6 Calibration gas challenges must be within the following ranges:

zero
0.030-0.080
0.150-0.200
0.350-0.450
0.800-0.900*

*Only if analyzer is operating in the zero to 1.0 ppm range.

4.4.7 To perform a multipoint calibration of the Model 42i, follow procedures in Chapter 4 of 42i manual and also refer to the Code of Federal Regulations, Title 40, Part 50, Appendix F.

The calibration technique is based on the rapid gas phase reaction between NO and O₃ which produces stoichiometric quantities of NO₂ in accordance with the reaction:



The quantitative nature of this reaction is such that when the NO concentration is known, the concentration of NO₂ can be determined. Ozone is added to excess NO in a dynamic calibration system, and the NO channel of the chemiluminescence NO-NO₂-NO_x analyzer is used as an indicator of changes in NO concentration.

When O₃ is added, the decrease in NO concentration observed on the calibrated NO channel is equivalent to the concentration of NO₂ produced.

Adding variable amounts of O₃ from a stable O₃ generator can change the amount of NO₂ generated. The section 4 in the 42i manual discusses the procedure for calibrating the instrument.

- "Pre-Calibration" on page 4-8 of the manual is the procedure used prior to calibrating the analyzer.
- "Calibration" on page 4-9 of the manual provides the recommended procedures for calibrating the analyzer.
- "Zero and Span Check" on page 4-22 of the manual provides the zero and span check procedure.

4.5 Gas Phase Titration

4.5.1 Fill out all heading information on the NO₂ Gas Phase Titration Form.

NOTE: IDENTIFY ALL STANDARDS BY SERIAL NUMBER, CALIBRATION DATE AND CONCENTRATION.

4.5.2 After obtaining a stable zero response from the analyzer, begin by challenging the analyzer at the highest NO dilution concentration.

4.5.3 Following stabilization of the analyzer to the 0.350 - 0.450 ppm no challenge, record the reported DAS values for the NO, NO_x and NO₂ channels in the appropriate spaces of the data form. Turn on the ozone. Ozone concentrations should initially be increased in approximately 100 ppb increments and then 25 ppb increments as the desired concentration is approached to avoid over-titration. Titration should be monitored on the NO channel and should continue to within approximately 10% of the NO input.

NOTE: A record of laboratory verification of the ozone generator will be found with the calibration documentation for the dilution unit.

4.5.4 Allow the titration point to stabilize and record reported DAS values for the NO, NO_x and NO₂ channels percent full scale for the NO₂ and NO_x channels in the appropriate spaces of the data form. Shut off the ozone.

4.5.5 Adjust the dilution system to deliver an NO concentration of approximately 0.200 ppm. Following stabilization of the instrument response to this challenge, record the reported DAS values for the NO, NO_x and NO₂ channels percent full scale for the NO₂ and NO_x channels in the appropriate spaces of the data form. At this point, turn on the ozone and titrate to approximately 0.080 ppm of the NO channel (i.e., approximately 0.120 ppm NO "left"), allow the instrument response to stabilize and record the reported DAS values as above.

4.5.6 The final titration point should now be obtained by turning up the ozone until approximately 10% of the NO input remains. Allow the instrument response to stabilize and record DAS values as above. Shut off the ozone.

4.5.7 Adjust the dilution system to deliver the final NO audit concentration of approximately 0.080 ppm. Allow the instrument response to stabilize and record DAS values as above.

4.5.8 Determination of NO₂ Input

Perform a linear regression of the NO channel audit records, designating the NO input ppm "Y" and NO response ppm "X". You will obtain an equation in the form:

$$Y = MX + B$$

$$\text{or NO input} = M (\text{NO response}) + b.$$

Determine the true remaining NO concentration from the NO channel response to GPT using this relationship. then subtract that value from the known (calculated) input NO concentration before the ozone was turned on.

Example 1 - Linear Regression

if NO input = 1.153 x NO response - 0.002 ppm, and NO channel response to GPT = 0.205 ppm, then true remaining NO during GPT = 0.234 ppm.

Use this NO channel response curve to find the NO input value that corresponds to the NO response during GPT.

Example 2 - Graph (see Figure 5)

If the NO response is 0.205, Figure 5 indicates that the corresponding NO input is 0.239 ppm.

4.5.9 Determination of Converter Efficiency

Determine the converter efficiency at each of the titration points using the following equation:

$$\% C.E. = \left(1 - \frac{\Delta NO_x}{\Delta NO} \right) \times 100$$

Where:

ΔNO_x = the NO_x response before the ozone was introduced minus the NO_x response after stabilization on GPT,

ΔNO = the true NO input before the ozone was turned on minus the true NO input after stabilization on GPT. The true NO is that value determined in step 4.5.8.

NOTE: A converter efficiency of 96% or greater is considered satisfactory, otherwise, corrective action is required. Refer to the Thermo 42i instruction manual for troubleshooting information and corrective action procedures.

4.6 Verify the operation of the in-station calibration system according to ENSR SOP 2600, Field Calibration Control Plan.

4.7 Disengage the calibrator from the Thermo 42i and reconnect the analyzer to its normal ambient monitoring configuration.

5.0 QUALITY CONTROL

5.1 A multipoint calibration of the Thermo 42i must always leave the analyzer operating within $\pm 5.0\%$ of the calibration standard input at all points.

5.2 The converter efficiency must be demonstrated to be greater than 96.0%.

5.3 As soon as possible following calibration, the completed Gas Dilution Calibration and NO_2 Gas Phase Titration calibration forms should be submitted to the project manager, or designee, for review. Calibrator set points, dilution calculations and NO_2 inputs are to be reviewed for accuracy. Standards are to be reviewed for traceability and completeness. DAS and strip chart readings are to be reviewed for agreement and completeness.

6.0 DOCUMENTATION

6.1 All calibration data are to be recorded on the Gas Dilution Calibration and NO_2 Gas Phase Titration forms (Figures 3 and 4). These forms must be completed

and delivered to the project manager, or designee, for review. A copy of the forms must be maintained in the shelter.

6.2 All activities performed in the shelter must be documented in the Field Station Log, including date, technician initials and employee number, activities performed, the time the analyzer was taken off-line and then put back in service, calibration results as well as any other circumstances which may arise during the site visit.

6.3 In addition, if there is a strip chart recorder associated with the analyzer, the following information must be noted on the strip chart:

- date
- employee initials and number
- time off and back on line
- reason for taking the instrument off-line, and
- an explanation of each significant deflection of the pen.

7.0 REFERENCES

Thermo 42i instrument manual.

Figure 1
Flow Diagram

Figure 2
Thermo Electron Model 14/B/E NO-NO₂-NO_x Analyzer
Pneumatic System Diagram

Figure 3

Figure 4

Figure 5

SOP NUMBER: 2600-225**Operation, Calibration and
Maintenance of the Thermo
Environmental Model 43i SO₂
Analyzer****Date:** 4th Qtr., 2006**Revision Number:** 0**Author:** Vincent Scheetz**Discipline:** Air Measurements**1.0 PURPOSE AND APPLICABILITY**

The purpose of this document is to provide the procedures for the field use of the Thermo 43i SO₂ analyzer. This procedure conforms to the requirements of ENSR SOPs 2600, Field Calibration Control Plan and 2630, Routine Data Collection and Evaluation and applies to all individuals who are operating this analyzer according to current EPA guidelines.

This instrument is an EPA "equivalent analyzer" for monitoring SO₂ when operated under the following conditions:

- Ranges: 0.5 and 1.0 ppm
- Time Response: Fast and Slow
- Ambient Temperature: 20 - 30C
- With an Aromatic Hydrocarbon Cutter
- Line Voltage: 105 - 125 VAC

2.0 RESPONSIBILITIES**2.1 Field Technician**

- 2.1.1** It is the responsibility of the field technician to read and perform the operation in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.
- 2.1.2** It is also the responsibility of the field technician to document the procedure in the field station log as well as on any data forms contained within this procedure.
- 2.1.3** It is the responsibility of the field technician to read and perform the operations, including unpacking and installation, in accordance with the instruction manual for the Thermo Anderson Model 43i analyzer.

2.2 Project Manager

- 2.2.1** It is the responsibility of the project manager, or designee, to ensure that the operation is performed at the designated frequency and to ensure that all necessary equipment is available and properly certified.
- 2.2.2** It is the responsibility of the project manager, or designee, to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 SUPPORTING MATERIALS

- Model 43i instruction manual
- Leak checker capable of producing a negative pressure of 10 mmHg
- Fluke 8020A digital multimeter (DVM) or equivalent
- Gas Dilution System - (ENSR Gascal 82 or equivalent) and calibration data certified within the previous 3 months in accordance with ENSR SOP 2600
- SO₂ Gas Cylinder - 40-50 ppm NIST-traceable, certified within the previous 24 months using EPA Protocol 1
- Assorted hand tools
- ENSR SOP 2600, Field Calibration Control Plan
- ENSR SOP 2600-700, Operation of the ENSR Portable Field Calibration
- ENSR SOP 2630, Routine Data Collection and Evaluation System

4.0 METHOD

Prior to starting any calibration or calibration check as required for routine operation, perform maintenance tasks as required. Routine tasks include inspection of the flow capillary and replacement of the sample line filter. These tasks should be performed weekly.

4.1 Leak checking

It is advisable to perform a leak check on the pneumatics of the Thermo 43i when leaks are suspected as well as part of a multipoint calibration. This may be accomplished through the use of an ENSR leak check device or other suitable device capable of providing negative pressure for the purpose of leak checking.

- 4.1.1** Connect the leak check device to the EXHAUST port of the 43i and plug off all other ports.

NOTE: Leak checks should be performed with the analyzer power shut off.

- 4.1.2** Generate a negative pressure of approximately -10.0 "Hg and close off the valve to the analyzer.
- 4.1.3** Observe the gauge on the leak check device. The leak rate must be less than 1" per minute. If the rate of leakage is more than 1" per minute, tighten fittings and all connectors. If this does not fix the leak, apply a small positive pressure (less than 3.0 PSI) and use a leak detector fluid such as SNOOP or its equivalent to find the leak.
- 4.1.4** Disconnect the leak check device from the 43i and reconnect all ports.

CAUTION: DO NOT EXPOSE THE THERMO MODEL 43i TO MORE THAN 3.0 PSI POSITIVE PRESSURE OR LESS THAN -10.0 "Hg NEGATIVE PRESSURE

4.2 Operation

- 4.2.1** If initial start up of the instrument, allow at least 1 hour (preferably overnight) for the instrument to stabilize prior to calibration.
- 4.2.2** Set the range to the appropriate setting (0.5, 1.0 ppm). The operating range should be defined in the Project Monitoring or Quality Assurance Plans.
- 4.2.3** Set the time constant switch to either slow (4 minute response) or fast (2 minute response). During calibration it is recommended to choose the fast response time constant.

4.3 Calibration

- 4.3.1** Fill out the heading information of the Gas Dilution Calibration Form (Figure 1). Calculate the flow settings for the calibration system in order to produce the desired concentrations of SO₂ according to ENSR SOP 2600-700, Operation of the ENSR Portable Field Calibration System.
- 4.3.2** A minimum of 1600 cc/min dilution air flow is recommended to satisfy the analyzer flow requirement with excess flow vented to the atmosphere.

4.3.3 Calibration gas challenges must be within the following ranges:

zero
 0.030-0.080
 0.150-0.200
 0.350-0.450
 0.800-0.900*

* Only if analyzer is operating in the zero to 1.0 ppm range.

4.3.4 Dilution Calibration

The flow calculation when a dilution system is being used is:

$$C = \frac{C_{cyl} \times F_{SO_2}}{F_{SO_2} + F_D}$$

Where:

C = the desired SO₂ concentration (ppm)

C_{cyl} = the SO₂ concentration in the calibration gas cylinder (ppm)

F_{SO₂} = the flow of SO₂ gas from the gas cylinder (cc/min)

F_D = the flow of dilution air (cc/min)

4.3.5 Note start and end times of the calibration in the Field Station Log.

4.3.6 Analyzer Readings

In all cases analyzer readings should be taken from the DAS. System responses should be retrieved and recorded as five minute average readings. If five minute average readings are not available, DAS instantaneous voltage readings are to be retrieved, converted to ppm, and recorded once a stable response is observed. A response is considered stable when there has not been more than a 1.0% change over five minutes. DAS readings are used to determine system response and percent difference.

- 4.3.7** Set the calibration system to produce "zero" air. Connect the output of the calibrator to the SAMPLE inlet of the Thermo 43i through as much of the sample pneumatics as practical. Be certain that all filters and scrubbers usually in the system are included.
- 4.3.8** Vent the excess calibrator output with a manifold or tee to the exhaust system of the shelter. Keep the delivery pressure to the analyzer as close to atmospheric pressure as possible. Do not subject the analyzer to positive or negative pressures of more than 0.5" H₂O. When the analyzer has stabilized, record the output response in the appropriate space of the calibration form.
- 4.3.9** Following stabilization, set the background concentration. The SO₂ Background Correction is determined during zero calibration. The Calibrate SO₂ Background screen is used to adjust the SO₂ background, or perform a "zero calibration". Before performing a zero calibration, ensure the analyzer samples zero air for at least 5 minutes.
- In the Main Menu, choose Calibration > Cal SO₂ Background.*
- *Press to set the new reading to zero.*
 - *Press to return to the Calibration menu or to return to the Run screen.*
- 4.3.10** A calibration gas system capable of providing accurate levels of SO₂ calibration gas between zero and 80% of the full-scale range is required. The calibration system must provide a flow rate of at least 0.8 LPM for an instrument with the standard flow (instruments with higher flow rates will require a higher minimum calibration system flow rate). All calibration gas should be derived from local or working standards (such as cylinders of compressed gas or permeation devices) that are certified as traceable to an NIST primary standard.
- 4.3.11** Calculate the percent deviation of the analyzer from the designated input using the equation and procedure described in Section 4.7.5 of ENSR SOP 2600, Field Calibration Control Plan.
- 4.3.12** Repeat for each remaining required concentration. Refer to ENSR SOP 2600, Field Calibration Control Plan for procedures relating to the analyzer response percent difference from calculated input. A multipoint calibration must always leave the analyzer operating within $\pm 5.0\%$ of the reference calibrator at all concentrations.

- 4.3.13** If the instrument is equipped with the optional zero/span and sample valves, connect the zero and span gas to the rear panel bulkheads labeled ZERO and SPAN, otherwise connect a source of vented zero air to the SAMPLE bulkhead. The display keys are used to activate the zero and span valves. The lower left-hand corner of the Run screen indicates which mode is active: zero, span, or sample.
- 4.3.14** To ensure that the zero air is being measured at atmospheric pressure, check that the zero air flow is approximately 0.8 LPM (zero air flow must be slightly greater than instrument sample flow).
- 4.3.15** Press to monitor the zero air reading and wait for the reading to stabilize.
- 4.3.16** Generate five SO₂ concentrations equally spaced between zero and the concentration above.
- 4.3.17** Record instrument reading for each concentration after allowing time for both gas generation system and instrument to stabilize.
- 4.3.18** Plot a graph of instrument readings against the SO₂ concentrations generated for the high range. This is the instrument calibration curve. All future measurements should be interpreted using this curve.

5.0 QUALITY CONTROL

- 5.1** A multipoint calibration of a Thermo 43i SO₂ analyzer must always leave the analyzer operating within +/- 5.0% of the reference calibrator at all calibration inputs.
- 5.2** As soon as possible following calibration, the completed Gas Dilution Calibration form is to be submitted to the project manager or designee for review. Calibrator set points and dilution calculations are to be reviewed for accuracy. Standards are reviewed for traceability and completeness. DAS readings are to be reviewed for agreement and completeness.

6.0 DOCUMENTATION

Comprehensive documentation of the operation and calibration of the Thermo 43i is achieved by the completion of the following:

- Gas Dilution Calibration form (Figure 1)

- Noting the occurrence of calibration and maintenance tasks in the Field Station Log, including start and end times, results and any unusual circumstances which may affect the operation of the analyzer or collection of data.

7.0 REFERENCES

Thermo 43i instrument instruction manual

INSERT Figure 1 here.

SOP NUMBER: 2600-700

Operation of the ENSR Ambient Monitoring Portable Field Calibration Systems

Date: 2nd Qtr., 1994
Revision Number: 1
Author: Scott Whittemore
Discipline: Air Toxics Measurements

1.0 PURPOSE AND APPLICABILITY

This procedure provides instruction on the use of the ENSR portable field calibration systems 8570 and Gascal 82 and is to be used in conjunction with the individual analyzer specific calibration standard operating procedure (SOP). It is assumed that the portable system in use has been calibrated within the previous three months in accordance with ENSR SOP 2400, Traceability of Standards and that the current calibration data is available for reference. It is also assumed that during calibration all expendable scrubbing material in the clean air unit has been examined or recharged to ensure proper function.

2.0 RESPONSIBILITIES

2.1 Field Technician

- 2.1.1** It is the responsibility of the field technician to read and perform the operation in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.
- 2.1.2** It is also the responsibility of the field technician to document the procedure in the field station log as well as on any data forms contained or referred to within this procedure.

2.2 Project Manager

- 2.2.1** It is the responsibility of the project manager, or designee, to ensure that the operation is performed at the designated frequency and to ensure that all necessary equipment is available and properly certified.
- 2.2.2** It is the responsibility of the project manager, or designee, to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 REQUIRED MATERIALS

3.1 Tools/Materials

- ENSR portable field calibration system, calibrated within the previous three months, with calibration documentation
- Two crescent wrenches
- Assorted swagelock fittings particularly 1/8" and 1/4" nuts and ferrules (stainless steel)
- Approximately 5' of 1/8" teflon tubing
- Approximately 1`5' of 1/4" teflon tubing
- At least one fluoroware union tee or teflon manifold
- Gas cylinders, with associated certification documentation
- Pressure regulator for each gas cylinder to be used (with spare washers, if necessary)
- Jackknife or other tool for cutting tubing
- Spare activated charcoal column

3.2 Documents

- ENSR SOP 2400, Traceability of Standards
- Operation Manual for ENSR Portable Field Calibration System
- ENSR SOP specific to the individual analyzer under test

4.0 METHOD

4.1 Gas Dilution (with clean air unit)

- 4.1.1 Set the GCU on a level surface and the CAU on the floor, near the GCU. Connect 6-8 feet of 1/4" tubing to the AIR IN port of the CAU. Run this line outside of the shelter.
- 4.1.2 Connect 2-3 feet of 1/4" TFE tubing from the AIR OUT port of the CAU to the AIR IN port of the GCU.
- 4.1.3 Connect at least 3 feet of 1/4" TFE tubing to the AIR/SPAN OUT port of the GCU 8570. The other end of the tubing should be connected to a vent union TEE (S.S. or TFE). The Gascal 82 has a vent port built into the GCU which can be used to vent the delivery line rather than using a TEE.
- 4.1.4 Connect a length of tubing from the exhaust manifold to the port of the TEE straight across from the gas inlet. Connect the 3/8" vent line from the vent port of the Gascal 82 to the exhaust manifold.

- 4.1.5** Push the POWER switches off and plug the power cords from the units into 115 VAC 60 Hz power outlet. Turn on the GCU and allow approximately 30 minutes for warm-up.
- 4.1.6** Regulator Purge - Before using any gas from a cylinder, purge the regulator as follows:
- a. Purge all regulators outside the shelter.
 - b. Attach the regulator and delivery line to the cylinder. Use a teflon washer as necessary.
 - c. Close the delivery valve and open the regulator.
 - d. Close the cylinder and open the delivery line.
 - e. Repeat steps b and c at least five times.
 - f. With the regulator pressurized (cylinder open and the delivery valve closed), connect the delivery line to the gas inlet port on the dilution system. It is good practice to open the delivery valve as one is tightening the delivery line on the dilution system to purge the delivery line.
 - g. If, at any time, the regulator is de-pressurized, the purge procedure must be repeated.
- 4.1.7** Leave the SPAN OUT port of the GCU plugged, and turn the 3-way valve on the GCU 8570 to Dilution.
- 4.1.8** At the end of the warmup, turn the thumb wheel switch on the GCU to each of the ten positions. The user manual describes the function of each position. Switch positions 7, 8, 9, 0 are power supply values designated on the data card for the GCU. If the observed values are more than $\pm 10\%$ from the designated value, do not use the unit until it has been repaired. Position 4 of the GCU 8570 and position 8 of the Gascal 82 are the panel meter zero indicators and will determine whether or not an offset will be assigned to observed values.
- 4.1.9** Disconnect the sample line of the analyzer from the sample manifold (block the port on the manifold) and attach it to the port of the TEE perpendicular to the gas inlet port (see Figure 1). If using the Gascal 82, open the vent

and connect the delivery line directly into the particulate filter in the sample line of the analyzer.

4.1.10 If all the voltages are within $\pm 10.0\%$ of designated, turn on the CAU.

- Make sure the fan (visible on the front panel of the CAU) is working.
- Adjust the PRESSURE CONTROL for a reading of 30 psi on the gauge.

4.1.11 Adjust the AIR CONTROL on the GCU for a flow rate at least 20% greater than the sample flow of the analyzer. You are now conducting a dynamic zero check on the analyzer.

4.1.12 Wait for the analyzer to give a stable reading and then record the reading.

4.2 Calculations

4.2.1 The calibration gas concentrations for multipoint calibrations must be generated in the following ranges:

- 0.800 - 0.900 ppm*
- 0.400 - 0.450 ppm
- 0.150 - 0.200 ppm
- 0.030 - 0.080 ppm

*If analyzer is operating in the 0 - 1.0 ppm range.

4.2.2 The GCU has been designed for use with cylinder concentrations of 30 - 50 ppm and a dilution flow of 1-10 slpm. To generate a concentration ≥ 1.0 ppm, calculate the gas flow as follows:

$$GF = \frac{(DF_{cc/min}) \cdot (PPM_{OUT})}{[C] - PPM_{OUT}}$$

where

GF = gas flow, in cc/min
DF = dilution flow, in cc/min
PPM_{OUT} = concentration to be generated, in ppm
[C] = the cylinder concentration, in ppm

4.2.3 The lower limit of the useable range of the gas MFC is the lowest calibration point on its curve (~10-15 cc/min). With this minimum gas flow, it will be necessary to increase the dilution flow when generating output concentrations < 0.1 ppm from a 50 ppm cylinder. To determine the dilution

flow required with this minimum gas flow to generate an output concentration <0.1 ppm use the following two equations:

$$TF = \frac{[C] \cdot GF}{PPM_{OUT}}, \text{ and} \quad (1)$$

$$DF = TF - GF \quad (2)$$

where

TF = the total flow, in cc/min
[C] = cylinder concentration, ppm
GF = the gas flow, in cc/min
PPM_{OUT} = the concentration to be generated, in ppm
DF = the dilution flow required, in cc/min.

4.2.4 If the dilution flow computed in 4.2.3 is beyond the highest calibration point on the dilution flow controller calibration curve, repeat 4.2.3 for a slightly higher output concentration. Before proceeding to the next step, make sure the total flow (gas flow + dilution flow) is at least 20% greater than the sample flow of the analyzer.

4.2.5 When the correct flows have been determined, the corresponding mass flow controller (MFC) settings (panel display readings) must be determined as follows:

On the calibration documents for each MFC, find the linear regression equation relating flow rate to VDC. This equation has the form:

$$\text{Flow} = M \times \text{VDC} + B$$

Since the flow is known, this equation can be used to determine the panel display reading that corresponds to the flow by reversing it:

$$\text{VDC} = (\text{Flow} - B) / M$$

NOTE: In computing the display reading from the flow, be careful about the units. the air MFC is often calibrated in SLPM, rather than scc/min. Also avoid using flowrates beyond the highest or lowest calibration point for the MFC. Extrapolation of calibration curves is inaccurate, and should not be necessary to obtain the desired concentrations.

NOTE: Do not use flowrates less than 10% of MFC full scale.

- 4.2.6 When the flow settings have been computed, enter all flow settings as well as actual flows on the calibration form and set the GCU to produce the desired concentration.
- 4.2.7 Turn the thumb wheel switch on the GCU to the position labeled AIR FLOW. Unlock the AIR CONTROL of the 8570 and turn it until the setting computed in 4.2.5 for dilution flow appears in the display window. When this number appears and is stable, lock the AIR CONTROL. Turn the thumb wheel switch of the Gascal 82 to the COMMAND position 1 and turn the AIR CONTROL until the desired setting is observed. Switch the thumb wheel to position 2 and observe the actual air flow. Wait for the display to stabilize and adjust as necessary.
- 4.2.8 Open the gas cylinder (if you haven't already done so) and open the line valve. Adjust the line pressure to 20 psi. Turn the 3-way valve on the GCU 8570 to DILUTION.
- 4.2.9 Turn the thumb wheel switch to of the 8570 SPAN FLOW, unlock the SPAN CONTROL and turn it until the setting computed in 4.2.5 for gas flow appears in the display window. When this number appears and is stable, lock the SPAN CONTROL. Turn the thumb wheel switch of the Gascal 82 to the COMMAND position 3 and turn the Gas Control until the desired setting is observed. Switch the thumb wheel to position 4 and observe the actual gas flow. Wait for the display to stabilize and adjust as necessary.
- 4.2.10 When the analyzer reading has stabilized enter it on the form in volts and in ppm.
- 4.2.11 Repeat steps 4.2.6 through 4.2.11 for the remaining concentrations.
- 4.3 Gas Dilution (with clean air cylinder)
 - 4.3.1 Follow the same steps as in 4.1, but in place of the CAU, connect 3-4 feet of 1/4" tubing from the pressure regulator on the clean air cylinder to the AIR IN port of the GCU.
 - 4.3.2 Set the regulator for approximately 20 psi line pressure.
- 4.4 Gas Phase Titration (GPT)
 - 4.4.1 Gas phase titration is accomplished through the use of the separate titrator in the 8570 or the internal ozone lamp in the Gascal 82. If titration is being

performed using the 8570, the titrator must be plumbed in-line prior to the initiation of the dilution calibration as follows:

- 4.4.2** Follow the steps in 4.1.1, 4.1.2, and 4.1.6.
- 4.4.3** Using 1/4" teflon tubing, connect the AIR/SPAN OUT port on the GCU to the AIR IN port on the GTU.
- 4.4.4** Using 1/8" teflon tubing, connect the SPAN OUT port on the GCU to the SPAN IN port on the GTU.
- 4.4.5** Connect at least 3 feet of 1/4" TFE tubing to the PPM OUT port of the GTU. The other end of this line is connected to a vent union tee (S.S. or TFE).
- 4.4.6** Connect another length of 1/4" tubing from the exhaust manifold to the branch of the TEE directly opposite the gas inlet.
- 4.4.7** Disconnect the analyzer sample line from the manifold (block the port on the manifold) and connect it to the port of the TEE perpendicular to the gas inlet (see Figure 1).
- 4.4.8** Turn the 3-way valve on the GCU to DIRECT SPAN.
- 4.4.9** Place the POWER switch on the GTU in the OFF position. Plug the power cord from the unit into a 115 VAC, 60 Hz power outlet.
- 4.4.10** Turn on the GTU and GCU and allow the system to warm up for 15-20 minutes. Connect a double banana jack cable to the O₃ control REF or OZONATOR TEMP and the EXTERNAL input jack on the GCU. Be certain that polarity is matched when the connection is made.
- 4.4.11** A record of the laboratory verification of the ozone generator will be found in the calibration documentation of the calibrator. Approximate expected O₃ concentrations corresponding to selected settings of the thumb wheel ozone control can be found on that record.
- 4.4.12** Do not introduce a greater concentration of O₃ than NO. The highest concentrations should be at least 10% less than the NO concentration. The titration of O₃ into NO produces a violent reaction. The ozone should be introduced gradually and allowed to begin to stabilize before more ozone is added. Monitor the response of the NO channel to keep track of the reaction. As the NO channel response decreases, the NO₂ channel response will rise. Add more ozone only when the reaction "slows down" to avoid over-titrating. Also, be aware that the error ($\Delta\%$) of the NO channel

will affect the remaining NO as indicated by the NO channel and thus the NO₂ input.

- 4.4.13 Perform a gas dilution calibration or calibration check of the NO₂ analyzer prior to GPT to determine the initial calibration status of the analyzer. Refer to the individual analyzer specific SOP for instruction.
- 4.4.14 Allow adequate time for warm-up of the ozonator before recording the analyzer response (refer to the manual). Until the ozonator is warmed up, a gradual drift of the analyzer response may be observed.

4.5 Care and Maintenance of System

- 4.5.1 ENSR Portable Field Calibration Systems are precision instruments and must be treated with care in order to perform well for any length of time. As with any other precision equipment, lack of caution in its handling will quickly lead to the need for costly repairs.
- 4.5.2 When using the CAU, always check the operation of the fan on the front panel. The power connector on the fan can come loose. When this happens, the air passing through the unit is not dried and moisture may get into the GCU.
- 4.5.3 Store the system in a dry environment.
- 4.5.4 Always keep all ports on the GCU and GTU blocked when not in use. This prevents foreign matter from finding its way into the plumbing.

5.0 QUALITY CONTROL

- 5.1 As soon as possible following calibration, the completed calibration form is to be submitted to the project manager or designee for review. Calibrator setpoints and dilution calculations are to be reviewed for accuracy. Standards are to be reviewed for traceability and completeness. DAS and strip chart readings are to be reviewed for agreement and completeness.

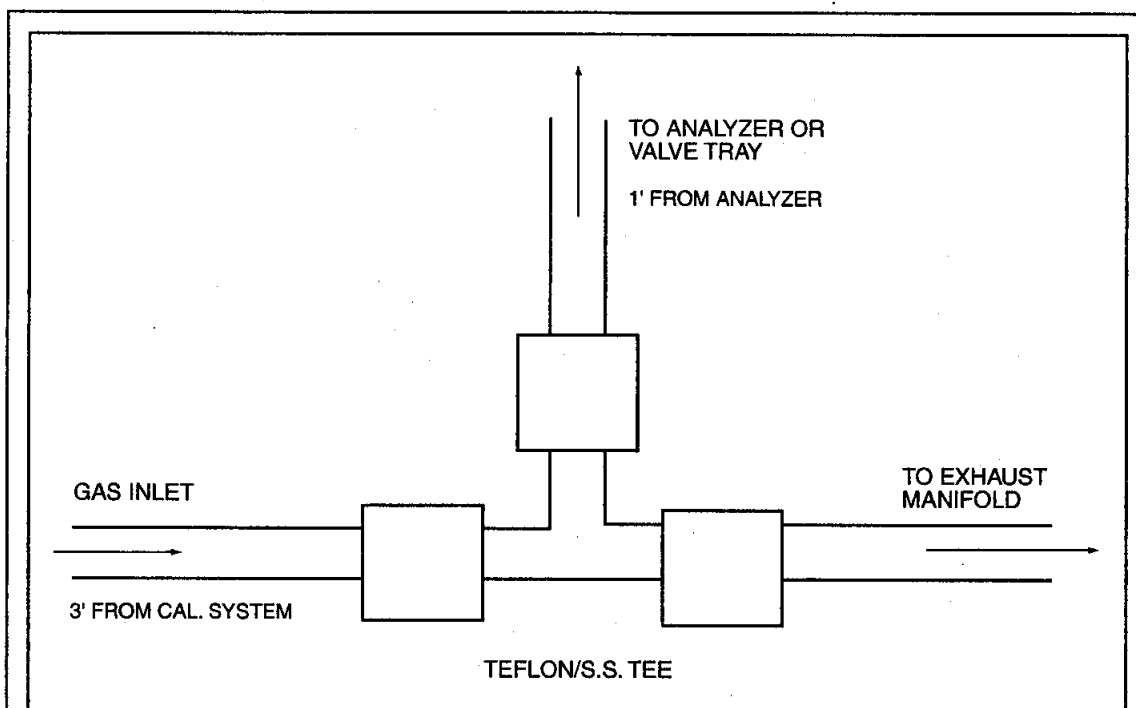
6.0 DOCUMENTATION

- 6.1 A copy of the completed calibration forms are to be left in the shelter.
- 6.2 Mark the strip chart recorder with start and end times of calibrations, or other task as well as an explanation of each significant deflection of the recorder pen.
- 6.3 Note the occurrence of calibration tasks in the Field Station Log.

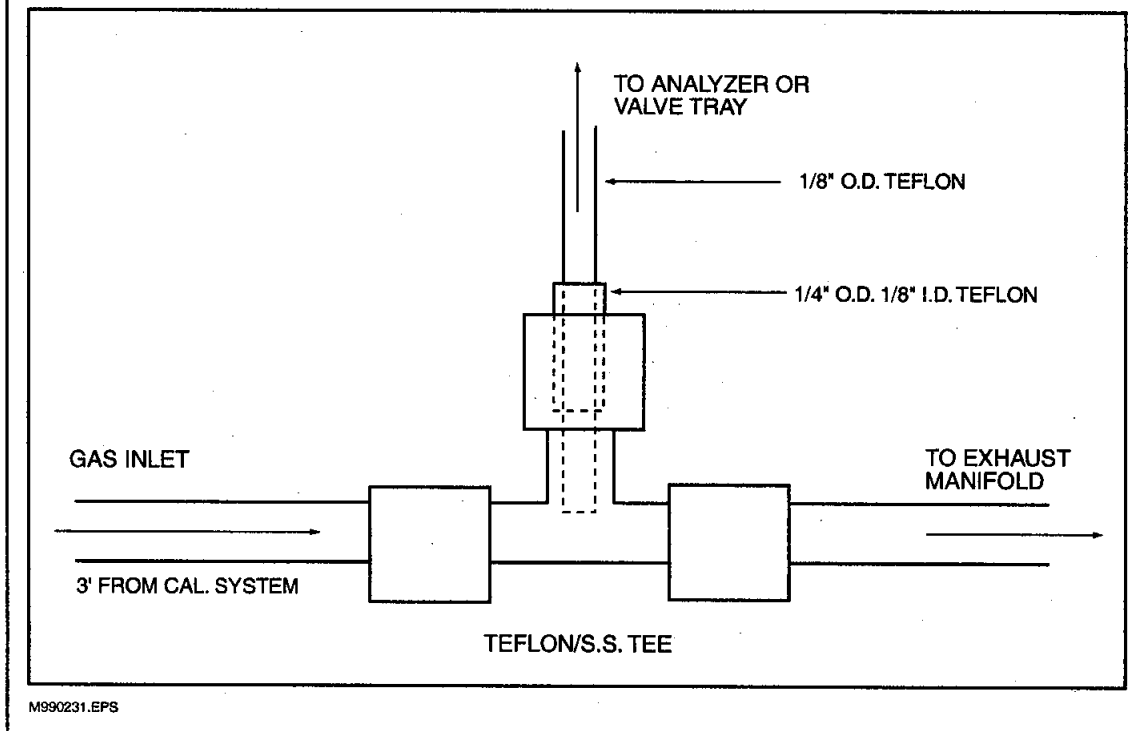
7.0 REFERENCES

- ENSR Portable Field Calibration System Instruction Manual

Figure 1
Schematic of Connections



* NOTE: ALL TUBING SHOULD BE 1/4" O.D. TEFLON



M990231.EPS

SOP NUMBER: 2620-001

High Volume Sampler Calibration for the Volumetrically Flow Controlled (VFC) Sampler

Date: 1st Qtr 2007
Revision Number: 8
Author: Mike O'Brien
 Vincent Scheetz
Discipline: Air Monitoring

1.0 PURPOSE AND APPLICABILITY

1.1 This Standard Operating Procedure (SOP) describes the steps necessary for quarterly (seasonal) calibrations of a VFC type High Volume (HI-VOL) sampler. This SOP is based on the methods detailed in the EPA Quality Assurance Handbook for Air Pollution measurement Systems Volume II, Section 2.11, EPA-600/R-94/038b, ORD and the Federal Reference Method described in Appendix B of 40 CFR 50. The VFC sampler calibration procedure presented in this section relates known flow rates (Q_a , as determined by an orifice transfer standard) to the ratio of the stagnation pressure to the ambient barometric pressure (P_1/P_a). The stagnation pressure (P_1) is the air pressure inside the sampler in the area just under the filter. VFC samplers have a stagnation pressure tap or port through which the stagnation pressure can be measured. The VFC sampler's flow control system is a choked-flow venturi. It must be precisely sized for a given average annual temperature and pressure because the operational flow rate cannot be adjusted by the user.

For this VFC calibration procedure, the following conditions are assumed:

- The VFC sampler uses a choked-flow venturi to control the actual volumetric flow rate.
- The sampler flow rate is measured by measuring the stagnation pressure ratio, and the sampler is not equipped with a continuous flow recorder.
- The sampler inlet is designed to operate at a constant actual volumetric flow rate of 1.13 m³/min, and the acceptable flow-rate range is ± 10 percent of this value.
- The transfer standard for the flow-rate calibration is an orifice device equipped with either a series of resistance plates or an integral variable-resistance valve. The pressure drop across the orifice is measured by an associated water or oil manometer.
- The sampler will be calibrated in actual volumetric flow-rate units (Q_a), and the orifice transfer standard is also calibrated in Q_a , as specified in Section 2.2 of the Quality Assurance Handbook.

1.2 Calibrations are performed:

- upon installation;
- every calendar quarter;
- after brush or motor change;
- whenever a 1 point QC check or audit indicates $\Delta\%$ of $> \pm 7.0\%$;
- after leak repair; and
- prior to takedown

2.0 RESPONSIBILITIES

2.1 Field Technician

- 2.1.1** It is the responsibility of the field technician to read and to operate, maintain, and calibrate the samplers in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.
- 2.1.2** It is also the responsibility of the field technician to document the procedure in the field station log as well as on any data forms contained within this procedure.

2.2 Project Manager

- 2.2.1** It is the responsibility of the project manager or designee to ensure that the calibration is performed at the designated frequency and to ensure that all necessary calibration equipment is available and properly certified.
- 2.2.2** It is the responsibility of the project manager or designee to ensure that calibration documentation and filter jackets are reviewed for accuracy and completeness and are reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.
- 2.2.3** The project manager (or designee) will determine site elevation, mean barometric pressure and seasonal mean temperature for each site where particulate measurement is conducted.

3.0 REQUIRED MATERIALS

- Electronic manometer or an associated water or oil manometer, with a 0- to 400-mm (0- to 16-in.) range and a minimum scale division of 2 mm (0.1 in.).
- A water or oil manometer, with a 0- to 200-mm (0- to 8-in.) range and a minimum scale division of 2 mm (0.1 in.) for measurement of the sampler exit orifice plenum pressure. This manometer should be associated with the sampler.
- Orifice transfer standard with calibration traceable to NIST calibrated within 1 year of use with built-in variable resistance.
- Look-up table (corrected to 25°C, 760 mmHg) for orifice calibrator
- High Volume Sampler calibration spreadsheet.
- NIST-traceable thermometer (or equivalent) for ambient temperature readings. A thermometer capable of accurately measuring ambient air temperatures over a range of 0 to 50 °C to the nearest 0.1°C. This thermometer should be traceable with an accuracy of 0.1 °C to a NIST-certified thermometer or an ASTM thermometer.

- A portable aneroid barometer capable of accurately measuring ambient barometric pressure over the range of 500 to 800 mm Hg (66 to 106 kPa) to the nearest mm Hg and referenced within ± 5 mm Hg of a barometer of known accuracy at least annually.
- Adapter plate appropriate to HI-VOL being calibrated
- Mean barometric pressure for site, as determined from Smithsonian tables of elevation vs. mean pressure
- Seasonal mean ambient temperature for the site, as determined from reliable climate information
- Clean quartz filters (ideally filter used for calibration should be from the same batch currently being used for sampling.)

4.0 METHOD

- 4.1.1** Perform any maintenance such as brush change, motor replacement or gasket replacement, etc. Any maintenance required for the size selective head should also be accomplished according to the instructions found in the appropriate manufacturer's operating manual prior to calibration.
- 4.1.2** Remove the filter hold-down frame and replace with calibrator assembly (and hold-down frame, as appropriate). Verify that the calibration orifice has been calibrated within the past year, that the lookup table is current, and is the proper document for the device being used. A clean filter must also be placed in the calibrator assembly under the orifice.
- 4.1.3** Connect the oil manometer with a piece of flexible tubing to the pressure tap near the top of the calibrator. Set scale to read "0" at the bottom of the water meniscus. Connect the electronic manometer to the indicated stagnation pressure port at the side of the sampler. (The "indicated" flow of the VFC sampler is measured as stagnation pressure which is accomplished through the pressure tap located downstream of the sample filter and upstream of the venturi type flow meter). Zero the manometer and place it preferably in the shade. Try to keep the manometer at a consistent temperature. (Note - electronic manometers are sensitive to changes in temperature and may drift.)
- 4.1.4** Fill out all of the heading information in the calibration spreadsheet (Figure 1). (It is typical to record readings in the field on paper to be entered into the spreadsheet later).
- 4.1.5** Place the thermometer in a shaded, well ventilated, place and wait for a stable reading. Obtain the temperature and record as Ambient Temperature (T_1). Obtain the barometric pressure from the portable barometer. Record Ambient Pressure (P_1).
- 4.1.6** Conduct a leak test by blocking the orifice with a large-diameter rubber stopper, wide duct tape, or other suitable means. Seal both orifice and stagnation pressure ports with rubber caps or similar devices. Turn on the sampler.

Caution: Avoid running the sampler for longer than 30 s at a time with the orifice blocked. This precaution will reduce the chance that the motor will be overheated due to the lack of cooling air. Such overheating can shorten the motor's lifetime. It can raise temperatures to the point of defeating the electrical insulation, which could result in fire or electric shock to the user.

Gently rock the orifice transfer standard and listen for a whistling sound that would indicate a leak in the system. Leaks are usually caused either by a damaged or missing gasket between the orifice transfer standard and the faceplate or by cross threading of the orifice transfer standard on the faceplate. All leaks must be eliminated before proceeding with the calibration. When the system is determined to be leak-free, turn off the sampler and unblock the orifice.

- 4.1.7** Turn on the HI-VOL and allow it to run for at least 5 minutes. Adjust the resistance (using the knob on top of the orifice) to the lowest resistance (highest flow-rate) position.
- 4.1.8** Read the differential pressure on the manometer. (Read the bottom of the water meniscus.) Differential pressure equals the sum of the water displacement (in inches) of both sides of the manometer; i.e., the total distance between meniscus levels. Record the orifice transfer standard's manometer reading, ΔH_2O , and the corresponding sampler relative stagnation pressure manometer reading, ΔP_{stg} , on the data sheet. (Relative stagnation pressure is a negative pressure [i.e., a vacuum] relative to atmospheric pressure as measured by a manometer with one leg open to the atmosphere.)

Note: Be sure to convert ΔP_{stg} to millimeters Hg using Equation (1) before recording the reading on the calibration data sheet:

$$mm\ Hg = 25.4\ (in.\ H_2O/13.6). \quad (1)$$

- 4.1.9** Adjust the calibration orifice and repeat for 4 additional pairs of readings. Take care to make no more than 0.1" adjustments in calibration orifice for each reading. Too large of an adjustment will load down the sampler's motor and will cause a non-linear calibration.
- 4.1.10** Plot the calibration data on a sheet of graph paper.

Note: The data should be plotted in the field as the calibration is occurring, rather than afterwards back at the laboratory.

- 4.1.11** Turn off the sampler and remove the orifice transfer standard. Install a clean filter on the sampler in the normal sampling mode (use a filter cassette if one is normally used). Turn on the sampler and allow it to warm up to operating temperature.
- 4.1.12** Read the relative stagnation pressure and record it on the data sheet in the row for the operational flow rate.
- 4.1.13** Perform the calibration calculations presented in Section 4.1.14.

- 4.1.14** Gather together all the calibration data, including the orifice transfer standard's calibration information and the sampler calibration data sheet.

Note: These calculations should be done at the time of the calibration, rather than later. This approach will allow additional calibration points to be taken if questions arise about the data that have already been obtained.

1. Verify that the orifice transfer standard calibration relationship is current and traceable to an acceptable primary standard.
2. Calculate and record $Q_a(\text{orifice})$ for each calibration point from the orifice calibration information and the following equation (2):

$$Q_a(\text{orifice}) = \{[\Delta H_2O(T_a/P_a)]^{1/2} - b\} \{1/m\} \quad (2)$$

Where:

$Q_a(\text{orifice})$ = actual volumetric flow rate as indicated by the transfer standard orifice, m^3/min
 ΔH_2O = pressure drop across the orifice, mm (or in.) H_2O
 T_a = ambient temperature during use, K ($K = ^\circ\text{C} + 273$)
 P_a = ambient barometric pressure during use, mm Hg (or kPa)
 b = intercept of the orifice transfer standard's calibration relationship
 m = slope of the orifice transfer standard's calibration relationship.

3. Calculate and record the value of the absolute stagnation pressure, P_1 , for each calibration point (equation 3):

$$P_1 = P_a - \Delta P_{\text{stg}} \quad (3)$$

Where:

P_1 = absolute stagnation pressure, mm Hg
 P_a = ambient barometric pressure, mm Hg
 ΔP_{stg} = relative stagnation pressure, mm Hg.

4. Calculate and record the stagnation pressure ratio:

$$\text{Stagnation pressure ratio} = P_1/P_a.$$

5. On a sheet of graph paper, plot the calculated orifice transfer standard's flow rates, $Q_a(\text{orifice})$, on the x-axis vs. the corresponding stagnation pressure ratios, P_1/P_a , on the y-axis. Draw a smooth curve through the plotted data. If necessary, extrapolate the curve to include the acceptable flow rate range.
6. Compare $Q_a(\text{orifice})$ for several points on the calibration plot with $Q_a(\text{sampler})$ determined from the factory calibration at T_a . Calculate the percentage difference between $Q_a(\text{orifice})$ and $Q_a(\text{sampler})$. If the agreement is within a few (i.e., 3 or 4) percent, the factory calibration is validated and may be used for subsequent sample periods.

7. If the agreement is not within a few percent, recheck the accuracy of the orifice transfer standard and recheck the calibration procedure. Look for leaks, manometer reading errors, incorrect temperature or pressure data, or miscalculations. Also check for abnormally low line voltage at the site (it should be at least 110 VAC), for the correct blower motor, and for the presence of a gasket between the motor and the choked-flow venturi. A factory calibration is not likely to be substantially incorrect, and any discrepancy of more than a few percent is probably due to some problem with the sampler or with the calibration procedure. However, if no errors or problems with the sampler or with the calibration can be found, generate a new calibration relationship as described in Subsection 2.4.4 of the EPA QA Handbook, Section 2.11 PM₁₀ Guidance.

5.0 QUALITY CONTROL

5.1 Accuracy (PSD Networks)

Accuracy of HI-VOLs is determined for PSD networks by an independent performance audit, using an orifice calibrator different from that used in calibration of the HI-VOL. The audit flow is determined by relating the manometer reading to the orifice look-up table and determining actual flow rate. The sampler flow is then determined from the HI-VOL curve in current use, using the indicated flow gauge used during normal sampling. If the observed flow readings are $\geq \pm 7.0\%$ different from the audit flows, the HI-VOL should be calibration-checked by the technician, and repaired and recalibrated if necessary. Accuracy is reported quarterly as part of the audit report.

5.2 Precision (PSD Networks)

Precision data for PSD sites are collected by operating two collocated (i.e., at the same site) HI-VOLs, establishing $\Delta\%$ of TSP values and calculating 95% probability limits, using the data from both HI-VOLs. The method to be used is detailed in 40 CFR 58, Appendix A, Precision data are reported quarterly with the TSP or PM₁₀ data.

5.3 QC Review Criteria

The following criteria should be observed in QC review of HI-VOL calibration curves and filter jackets. It is not recommended that the filters themselves be inspected in the field because handling of samples between the sampler and the lab must be kept to a minimum to avoid damage to samples. Inspection of the filters will be performed during processing.

5.3.1 Filter Jackets

- Sampling time must be 1440 ± 60 minutes.
- Initial and final flowrate for the PM₁₀ samplers should be between 36-44 ACFM.
- Start and Stop sample times must be recorded on the jacketed.

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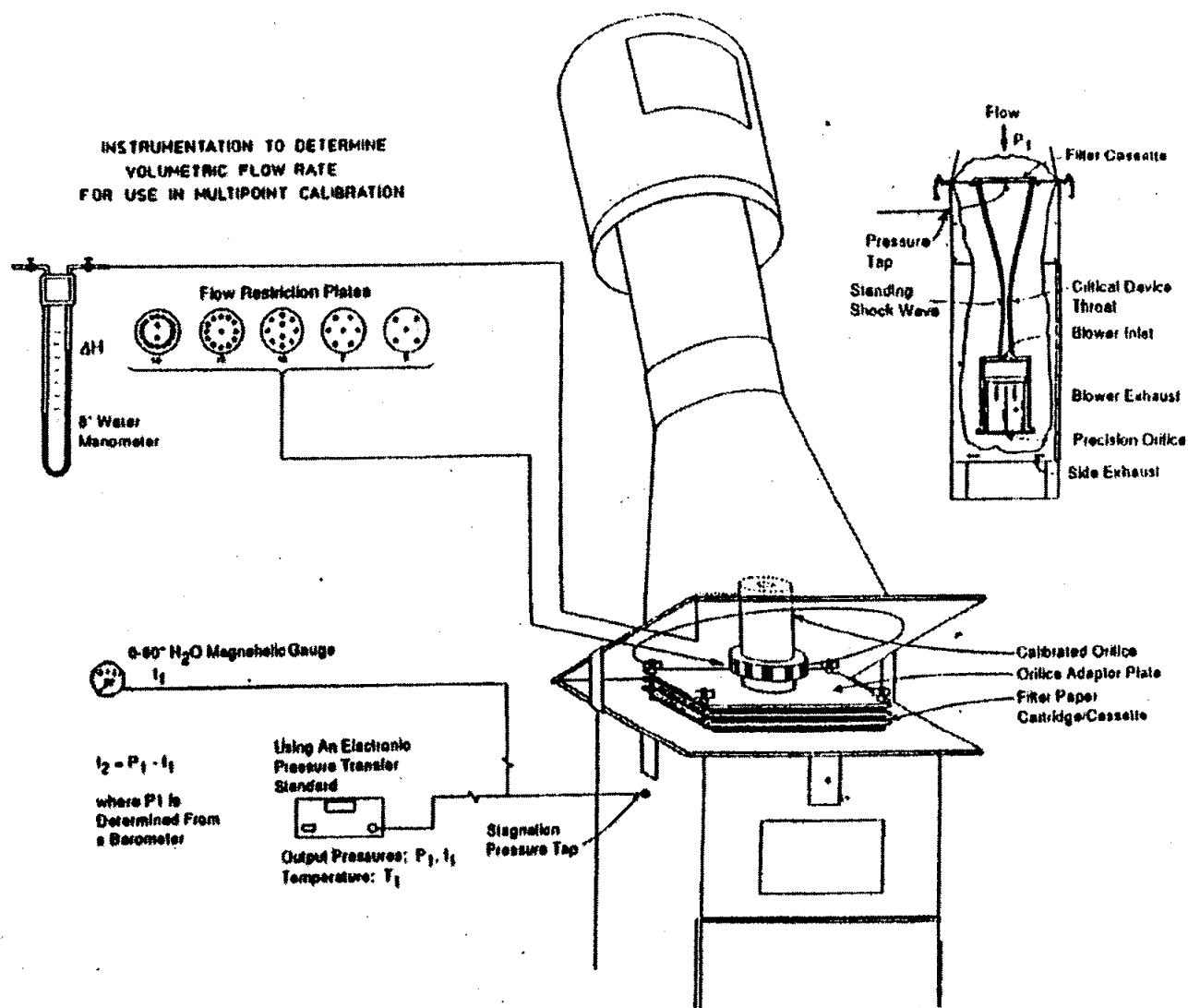
- Documentation on the filter jacket must be complete and consistent with the corresponding sampler documentation.

6.0 REFERENCES

U.S. Environmental Protection Agency. 1994. Quality Assurance Handbook for Air Pollution Measurement Systems Volume II, Section 2.11, EPA-600/R-94/038b, ORD, Washington, DC 20460

Code of Federal Regulations 40 CFR, Part 58, Appendix A, October 2006

U.S. Environmental Protection Agency. 1997. *Code of Federal Regulations*. Title 40, Chapter I, Subchapter C, Part 50, Appendix M. Washington, DC. Office of the Federal Register.

**FIGURE 2**

Instrumentation to Determine Volumetric Flow Rate
for Use in Multipoint Calibration

TABLE 1

Site Elevation (Feet above sea level)	Approximate Mean Barometric Pressure (mmHg)
0	760
500	746
1000	733
1500	720
2000	705
2500	694
3000	680
3500	669
4000	656
4500	644
5000	632
5500	620
6000	609
6500	598
7000	586
7500	575
8000	564
8500	554
9000	543
9500	533
10000	523

TABLE 2
Correction Factors for NWS Pressures

Site Elevation above Mean Sea Level		Correction Factor
Ft.	Meters	
11000	3353	0.661
10500	3200	0.674
10000	3048	0.688
9500	2896	0.701
9000	2743	0.715
8500	2591	0.779
8000	2438	0.743
7500	2286	0.757
7000	2134	0.771
6500	1981	0.786
6000	1829	0.801
5500	1676	0.817
5000	1524	0.832
4500	1372	0.848
4000	1219	0.864
3500	1067	0.880
3000	914	0.896
2500	762	0.913
2000	610	0.930
1500	475	0.947
1000	305	0.964
500	152	0.982
0	0	1.000

TABLE 3

Silicone Oil Retreatment Schedule for
PM₁₀ Size Selective Inlet

Sampling Frequency	Average TSP at Site ($\mu\text{g}/\text{m}^3$)	Retreatment Schedule
Daily	40	2 months
	75	1 month
	150	2 weeks
	200	weekly
Every 2 nd Day	40	3 months
	75	2 months
	150	monthly
	200	2 weeks
Every 3 rd Day	40	5 months
	75	3 months
	150	2 months
	200	monthly
Every 6 th Day	40	10 months
	75	5 months
	150	3 months
	200	2 months

SOP NUMBER: 2620-002**High Volume Sample Collection****Date:** 3rd Qtr 2006**Revision Number:** 5**Author:** Mike O'Brien
Vince Scheetz**Discipline:** Air Monitoring**1.0 PURPOSE AND APPLICABILITY**

This procedure applies to collection of suspended particulate using a standard glass fiber filter or micro quartz filter on a Volumetrically Flow Controlled (VFC) Sampler. This SOP conforms to the provisions of ENSR SOP 2620-001, High Volume Sampler Calibration for the Volumetrically Flow Controlled (VFC) Sampler.

2.0 RESPONSIBILITIES**2.1 Field Technician**

2.1.1 It is the responsibility of the field technician to read and to operate, maintain, and calibrate the samplers in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.

2.1.2 It is also the responsibility of the field technician to document the procedure in the field station log as well as on any data forms contained within this procedure.

2.2 Project Manager

2.2.1 It is the responsibility of the project manager or designee to ensure that the calibration is performed at the designated frequency and to ensure that all necessary calibration equipment is available and properly certified.

2.2.2 It is the responsibility of the project manager or designee to ensure that calibration documentation and filter jackets are reviewed for accuracy and completeness and are reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

2.2.3 The project manager (or designee) will determine site elevation, mean barometric pressure and seasonal mean temperature for each site where particulate measurement is conducted.

3.0 SUPPORTING MATERIALS

- Electronic manometer. (same as the one used for calibration).
- Supply of clean numbered filters (8"x10" fiberglass) in filter jackets.

- Thermometer accurate to ± 2 °C, or other accurate temperature reading (e.g., National Weather Service - NWS).
- Aneroid barometer or barometric pressure reading from local source (station pressure)

4.0 METHOD

The following instructions assume a continuous operation; that is, sampling is already underway, and exposed filters must be removed and replaced with clean filters.

NOTE: Filter jacket section numbers refer to the sample filter jacket in Figure 1.

The average actual flow rate for VFC samplers is calculated by determining (1) the average of the initial and final relative stagnation pressures ($\bar{A}P_{stg}$), (2) the average ambient temperature (T_{av}), and (3) the average barometric pressure (P_{av}) during the sampling period and then by applying these values to the calibration relationship.

Note: Consistency of temperature and barometric pressure units is required. All temperatures are to be expressed in Kelvin ($K = ^\circ C + 273$) and all barometric pressures in mm Hg.

4.1 Clean Filter Inspection and Identification

4.1.1 For the new filter to be installed:

- Clean Filter Intact: Check to see that the new filter has no holes or tears. Look especially at and around the serial number stamp. Also check to see that the filter is of the same general quality as other filters
- Serial Number Check: Is the serial number of the filter the same as the serial number on the filter jacket upper right hand corner?
- Initial Weight Indicated: Does the filter have an "initial weight" value recorded on the filter jacket?
- Filter Batch #: Should be recorded on the jacket.

If any of these checks fail, discard or set aside the filter and jacket, as appropriate.

4.2 Filter Installation Procedure

- Following the manufacturer's instructions, loosen the nuts that secure the inlet to the base and
- gently tilt back the inlet to allow access to the filter support screen.
- Examine the filter support screen. If the screen appears dirty, wipe it clean. If the filter cassette is
- equipped with a protective cover, remove it and place the loaded cassette in position on the
- sampler support screen. Tighten the thumb nuts sufficiently to hold the filter cassette securely.

- Check that the gasket is in good condition and has not deteriorated.

Caution: Tighten the thumb nuts evenly on alternate corners to properly align and seat the gasket. The nuts should be only hand-tightened because too much compression can damage the sealing gasket.

- Lower the sample inlet and secure it to the sampler base. Secure the sampler inlet to the sampler base.
- Turn on the sampler and allow it to reach a stable operating temperature (3 to 5 min).
- While the sampler is warming up, record the following parameters on the VFC filter jacket (Figure 1):
 - Site location
 - Sample date
 - Filter ID number
 - Sampler model and S/N
 - Operator's initials.
- Choose the manometer with a range 0 to 1,000 mm (0 to 36 in.) and a minimum scale division of 2 mm (0.1 in.). Inspect the manometer for crimps or cracks in its connecting tubing. Open the valves and blow gently through the tubing of the manometer, while watching for the free flow of the fluid.
- Adjust the manometer's sliding scale so that its zero line is at the bottom of the meniscuses.
- Remove the vacuum cap from the stagnation pressure port located on the side of the sampler base.
- Using the connecting tubing, attach one side of the manometer to the port. Leave the other side of the manometer open to atmospheric pressure. Make sure the tubing snugly fits the port and the manometer.
- Measure the initial relative stagnation pressure (ΔP_{stg}) and record this reading on the VFC Sampler Field Data Sheet.

Note: Be sure to convert the manometer reading to mm Hg using Equation (1) before recording the reading on the VFC Sampler Field Data Sheet.

$$\text{mm Hg} = (25.4) (\text{in. H}_2\text{O}/13.6) . \quad (1)$$

- Turn off the sampler, disconnect the manometer, and replace the vacuum cap on the stagnation pressure port.
- Set the sampler timer for the next run day.
- The sampler is now ready to sample ambient air.

4.2.1 Be sure to complete Sections 1, 2, 3, and 4 of the new filter jacket.

4.3 Exposed Filter End Time

Complete Section 8 of the exposed filter jacket, end time, by recording the elapsed time meter reading or the end time (1440 ± 60 min).

4.4 Timer Check

- Time Meters OK: Cycle each of the HI-VOLs briefly (if there are multiple samples) to note if the elapsed time meters operate when the HI-VOL is running.

- Timer OK: Check to see that the 24 hour or 7 day timer time is the same as the time of day (± 15 min.) also verify that the timer is set to start/stop at midnight ± 30 min.

If either check fails, reset, repair or replace timer, as necessary.

4.5 Clean Filter Start Time

Determine start time, Section 5. For a site with elapsed time meters, record the meter reading for the HI-VOL about to be loaded with a clean filter. (It should not be running.) For a single HI-VOL with a 7 day timer, record midnight (0001) in Section 5.

4.6 Flows and Filter Change

4.6.1 Completed Filter Final Flow

Attach the electronic manometer to the pressure stagnation port located on the side of the sampler. Turn on the HI-VOL, wait for a stable reading and record the reading in Section 9 of the exposed filter jacket.

Note: Electronic manometer should be zeroed prior to use and be placed on their backs on a flat surface for reading.

- 4.6.2** Record the ambient temperature ($^{\circ}\text{C}$) in Section 14 of the exposed filter jacket. Record the barometric pressure (mm Hg) in Section 10 of the exposed filter jacket. This reading should be obtained from the nearest National Weather Service (NWS) station and multiplied by the correction factor corresponding to your site elevation in Table 1. If you take the reading from a barometer at the site, do not apply any correction factor to the pressure reading.

- 4.6.3** Remove the used filter carefully by its edges. If weather conditions allow, inspect the filter. Is there a clean definition between the dirty portion of the filter and the border of the filter? If there is a streak on the filter border, note on the filter jacket, Section 13, change the gasket of the hold down frame and log the change in the station log. Fold the filter, dirty side in, and place it in the filter jacket.

Observe conditions around the monitoring site; note any activities that may affect filter particle loading (paving, mowing, fire) and record this information on the filter jacket.

NOTE: During humid weather, there is sometimes a tendency for the filter to stick to the hold down frame gasket. This situation can be alleviated by weekly treatment of the gasket with a silicone wipe cloth.

4.6.4 Clean Filter Installation

Remove the clean filter from its filter jacket, and carefully place on the HI-VOL backing screen with the smooth side on the screen. Replace the hold down frame

and tighten by hand so that equal pressure is applied to the entire sealing edge of the gasket.

If you are using cassettes, the filter should be pre-mounted and installed directly.

Now that the clean filter is in place, measure the flow with the magnehelic gauge (or equivalent). Record the reading in Section 6 on the filter jacket. Record ambient temperature in Section 15 of clean filter jacket. Enter the correct barometric pressure (see 4.5.2) in Section 7 of the clean filter jacket. The value recorded is the uncorrected gauge reading as in Section 4.6.1.

Cycle the HI-VOL system back to the unit which was sampling.

4.7 Validation of Exposed Filter Data

IT IS IMPORTANT THAT DATA VALIDATION BE PERFORMED IMMEDIATELY FOLLOWING FILTER CHANGE, IN ORDER TO DETECT AND CORRECT CONDITIONS ADVERSELY AFFECTING THE DATA BEFORE ADDITIONAL DATA ARE LOST. EVEN IF THE AVERAGE INITIAL AND FINAL FLOW VALUES ARE NOT AVAILABLE, ALL OTHER CHECKS SHOULD BE PERFORMED.

- 4.7.1 Inspect the completed filter for holes, tears and strange materials such as bugs, pollen, etc. Note unusual conditions on the filter jacket. (Also perform the edge inspection described in Section 4.6.3, if weather did not permit inspection at that time.)
- 4.7.2 Indicate on the jacket if the sample was taken during adverse weather conditions, such as rain or snow.
- 4.7.3 Subtract the "Start Time" reading from the "End Time" reading and log on the jacket in Section 11. Sample time must be 1440 ± 60 minutes for valid data. If not 1440 ± 60 minutes, the timer or the elapsed time meter may be faulty. Log the probable reason if the time is not within requirements and take corrective action, if necessary.

Note: In the case of an apparent elapsed time meter failure, the data may be considered valid if all other indications are that the sample time did meet criteria. If the 24 hour timer is still working and set to the correct time of day, and the sample appears to have started at midnight the sample should be labeled suspect in Section 13 of the filter jacket.

- 4.7.4 Check to see that the date of the calibration curve used is the date of the last calibration of the HI-VOL and is indicated on the filter jacket in Section 12. If the calibration is over 3 months old, perform a new calibration (ENSR SOP 2620-001) as soon as possible.

Record the actual flowrate in Section 16 on the filter jacket of the used filter. If it is a flow-controlled HI-VOL, write the flow controller set point next to the initial and final

flowrates and circle it. Observed flowrates must be within 4 cfm of the flow controller set point. This is not necessarily cause for invalidation of data. Possible reasons for the variation must be investigated and logged on the filter jacket in Section 13. Investigation should include a sampler calibration check. If the HI-VOL has a size selective head the flow rate must be within ± 4 cfm of the set point or the sample will be invalid.

4.7.5 If the filter has met the criteria in 4.6.1 through 4.6.4 then it is a valid sample. Check the "valid" box in Section 13.

4.7.6 If any of the above checks fails, double check calculations and flows read from the graph. If no errors are found, continue investigation until the problem is found and corrected.

4.8 Clean Filter - Initial Flowrate Check

4.8.1 Enter the date of the calibration curve used on the new filter jacket in Section 12. Check to see that the date of the curve used is the date of the last calibration of the HI-VOL, and is for the correct HI-VOL system.

4.8.2 Convert the initial observed flow reading to true flow and record in Section 17.

4.8.3 Most PM₁₀ HI-VOLs are designed to operate at 40 ACFM ± 4 . If flowrates are close to or outside these limits, check the batch number of the filter. If it is different from the preceding filter, the problem may be the filter. In any case, try a different filter and return to Section 4.1. If a second filter fails this initial flowrate criterion, perform a one point calibration check. If the point is within $\pm 7\%$ of the same point on the calibration curve, the problem is with the filter, not the HI-VOL. If it lies outside the $\pm 7\%$ limit, investigate and recalibrate the HI-VOL if necessary before any more samples are run.

Some filter batches have a pressure drop characteristic noticeably lower than others. Check the batch number of the problem filter, and check to see if it is covered by an exception to the initial flow criterion. If it falls within the "exceptional" range, consider it valid and proceed. Otherwise it is invalid. Report the problem to your supervisor if you cannot find a clean filter which will pass the appropriate flowrate criteria.

4.8.4 If initial flowrate is within the acceptance range the filter may be used for sampling.

5.0 QUALITY CONTROL

5.1 Validity Criteria - Summary

- PM₁₀ HI-VOLS are usually designed to operate at 40 ACFM ± 4 .

- Sample start/end time is midnight \pm 30 min.
- Duration of sampling time 1440 min. \pm 60 min.
- Filter intact (i.e., no holes present during sampling).
- Flowrates determined from a valid calibration curve.

If any one of these criteria are not met, the sample is INVALID. Any other conditions may be cause to label the data suspect, but not invalid. The following is a list of typical suspect conditions:

- Observed initial and final flowrates on a flow-controlled HI-VOL not within 4 ACFM of the flow controller set point.
- Water spots on filter.
- Insects on filter.
- Elapsed time meter failure, when 24 hour timer still works.

These and any other informative comments must be included under "comments" whenever data are suspect.

6.0 DOCUMENTATION

Documentation requirements for the filter jackets are described within Section 4.0.

7.0 REFERENCES

U.S. Environmental Protection Agency. 1994. Quality Assurance Handbook for Air Pollution Measurement Systems Volume II, Section 2.11, EPA-600/R-94/038b, ORD, Washington, DC 20460

TABLE 1
Correction Factors for NWS Pressures

Site Elevation above Mean Sea Level		Correction Factor
Ft.	Meters	
11000	3353	0.661
10500	3200	0.674
10000	3048	0.688
9500	2896	0.701
9000	2743	0.715
8500	2591	0.779
8000	2438	0.743
7500	2286	0.757
7000	2134	0.771
6500	1981	0.786
6000	1829	0.801
5500	1676	0.817
5000	1524	0.832
4500	1372	0.848
4000	1219	0.864
3500	1067	0.880
3000	914	0.896
2500	762	0.913
2000	610	0.930
1500	475	0.947
1000	305	0.964
500	152	0.982
0	0	1.000



ENSR Consulting and Engineering

SOP NUMBER: 2620-002

Network:	①	Filter Batch				
Site Name & No.	①	Sample No.				
Date Sampled:	②	③ System No. 1 2 3 4	ENSR or ID No.	④		
End Time:	⑧	Final Flow Reading	⑨	Temp °C	⑭	Press mmHg ⑩ ACFM ⑮
Start Time:	⑤	Initial Flow Reading	⑥	Temp °C	⑮	Press mmHg ⑦ ACFM ⑰
△ Time:	⑪	Cal. Curve Date:	⑫			

Final Weight:		Date Weighed:	
Initial Weight:		Date Weighed:	
△ Weight:		TSP Value:	

Valid ()	Invalid ()	Technician's Signature	
Comments:		⑬	

1. Use this filter only if the sample number and initial weight are recorded above.
2. Install filter with smooth (numbered) side down.
3. When sampling has been completed, every space in the first block should be filled in, and data classified in 3rd block.
4. Return filters to ENSR every week.

Flow Reading Conversion

$$I_c = \frac{P_1 \cdot [\text{Flow Reading} \times 1.87]}{P_i}$$

I_c Final _____

I_c Initial _____

MB31016

SOP NUMBER: 2620-071**High Volume Timer Field Calibration****Date:** 2nd Qtr., 1993**Revision Number:** 1**Author:** Mike Dobrowolski**Discipline:** Quality Assurance**1.0 PURPOSE AND APPLICABILITY**

The procedure described in this Standard Operating Procedure (SOP) is to be followed for the calibration of HI-VOL timers. It is based on the methods detailed in the EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 2.2.

2.0 RESPONSIBILITIES**2.1 Field Technician**

- 2.1.1** It is the responsibility of the field technician to read and perform the calibration in accordance with the methods and requirements specified in this and all referenced ENSR Standard Procedures.
- 2.1.2** It is also the responsibility of the field technician to document the procedure in the field station log as well as on any data forms contained within this procedure.

2.2 Project Manager

- 2.2.1** It is the responsibility of the project manager or designee to ensure that the calibration is performed at the designated frequency and to ensure that all necessary calibration equipment is available and properly certified.
- 2.2.2** It is the responsibility of the project manager or designee to ensure that all applicable calibration documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 REQUIRED MATERIALS

A reference General Time Model EF2733 elapsed time meter or equivalent that has been certified such that the gain or loss is ± 2 minutes in 24 hours.

4.0 METHOD

4.1 Elapsed Time Meter (Synchronous motor type 60Hz)

- 4.1.1** Fill out the heading of the Timer Calibration form (Figure 1).
- 4.1.2** Every 6 months connect a reference elapsed time meter, such as a General Time EF2733 or equivalent, in series with the sampler elapsed time meter using a cube tap or multiple outlet extension cord. The power cord should be of sufficient length to allow the reference elapsed time meter to operate inside the shelter.
- 4.1.3** Record the start times of both the test and reference elapsed time meters in the appropriate spaces of the Timer Calibration form.
- 4.1.4** Allow the system to operate for a 24 hour test period.
- 4.1.5** Record the end times of both the test and reference elapsed time meters in the appropriate spaces of the Timer Calibration form and determine the time elapsed on both meters.
- 4.1.6** The time meters must agree within +/- 2.0 minutes. If the meters do not agree within this tolerance, the test meter must be adjusted and re-tested. If the test time meter still does not agree after adjustment, it must be replaced.
- 4.1.7** If the timers agree, place a calibration sticker on the test elapsed time meter, note in the field station log that a calibration took place and include a copy of the calibration form in the next filter shipment to the laboratory. Retain a copy of the calibration data sheet at the site.

4.2 On-Off Timer

- 4.2.1** Fill out the heading of the Timer Calibration form (Figure 1).
- 4.2.2** On-Off timers are to be calibrated every 3 months against a currently calibrated elapsed time meter, either the sampler meter or a reference meter.
- 4.2.3** For multiple sampler systems, start the calibration with a system which is currently OFF but will operate during the next ON cycle.

- 4.2.4** For single sampler systems, the calibration will be conducted during the next ON cycle.
- 4.2.5** Record the start times of both the On-Off timer and the reference elapsed time meter in the appropriate spaces of the Timer Calibration form.
- 4.2.6** Allow the system to operate for a 24 hour test period.
- 4.2.7** Record the end times of both the On-Off timer reference elapsed time meter in the appropriate spaces of the Timer Calibration form and determine the time elapsed on both meters.
- 4.2.8** The time meters must agree within +/- 15.0 minutes. If the timers do not agree within this tolerance, adjust the tripper switches of the On-Off timer and repeat the test until the system operates within the tolerance.
- 4.2.9** When the timers agree, place a calibration sticker on the On-Off timer, note in the field station log that a calibration took place and include a copy of the calibration form in the next filter shipment to the laboratory. Retain a copy of the calibration data sheet at the site.

4.3 Reference Elapsed Time Meter

- 4.3.1** The accuracy of the reference elapsed time meter must be verified against a timepiece of known accuracy once every 6 months.
- 4.3.2** Record the start time of the test elapsed time meter.
- 4.3.3** Call the National Time Standard (303-499-7111) to receive current time.
- 4.3.4** Turn on the test elapsed time meter and allow it to operate for a 24 hour test period.
- 4.3.5** Call the National Time Standard and receive the current time.
- 4.3.6** Determine the elapsed time of the reference time source and the test time meter. The test meter must agree with the standard within +/- 2.0 minute/24 hours.

5.0 QUALITY CONTROL

- 5.1 Elapsed time meters are to be calibrated every 6 months against a reference standard accurate to within ± 2.0 min/24 hours. The test elapsed time meter must agree with the reference meter within ± 2.0 min/24 hours.
- 5.2 On-Off timers must be calibrated every three months against a currently certified sampler elapsed time meter or a calibrated reference elapsed time meter accurate to within ± 2.0 min/24 hours. The On-Off timer must agree within ± 15.0 min/24 hours.
- 5.3 The accuracy of the reference elapsed time meter must be verified against the National Time Standard every 6 months. The reference elapsed time meter must agree within ± 2.0 min/24 hours.

6.0 DOCUMENTATION

- 6.1 All calibration documentation is to be recorded on the Timer Calibration form (Figure 1). One copy of this calibration form is to be returned to the TSP laboratory with the next batch of filters and another is to be maintained at the site.
- 6.2 Record an entry in the field station log indicating the dates and times of the timer calibration.
- 6.3 Affix a calibration sticker to the calibrated timer.

7.0 REFERENCES

*Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 2.2. EPA-600/4-77-027a January, 1983.

SOP NUMBER: 2629-201

Filter Processing Method for the Determination of Suspended Particulates in Ambient Air

Date: 1st Qtr. 2007
Revision Number: 7
Author: Vincent Scheetz
Discipline: Air Quality Measurements

1.0 PURPOSE AND APPLICABILITY

- 1.1** This procedure describes the laboratory operations for the processing of the 8" x 10" glass fiber (TSP) and quartz (PM₁₀) HIVOL filters before and after sampling. The data obtained in these operations are used for the calculation of Total Suspended Particulate Matter (TSP) or PM₁₀ concentrations in ambient air. A flow diagram of the filter processing procedure is presented in Figure 1.
- 1.2** Total Suspended Particulate (TSP) is that portion of ambient suspended particulate matter which is normally collected on a high volume glass filter for 24 hours or specific project selected sample time and has an approximate 50% cut-size of 40µm.
- 1.3** PM₁₀ is that portion of ambient suspended particulate matter which is normally collected on a high volume quartz filter for 24 hours or specific product selected sample time through a size selective head mounted on a standard high volume sampler and has an approximate 50% cut-size of 10µm.
- 1.4** Air is drawn into a covered housing and through a filter by means of a high flow rate blower to collect suspended particulates having aerodynamic diameters of 0 to 40µm. HIVOLS fitted with size selective heads (PM₁₀) are operated to exclude particles above an aerodynamic diameter of 10µm.
- 1.5** When the sampler is operated at its nominal flow rate (39-60 scfm for General Metals style or 40 scfm ±4 for volume controlled hivols) for 24 hours, an adequate sample is obtained to detect concentrations as low as 1 µg/m³. The TSP & PM₁₀ concentrations in ambient air are computed by measuring the mass of collected particulates and the volume of air sampled. In calculating and reporting data, weights are determined to the nearest tenth of a milligram and mass concentrations are reported to the nearest microgram per cubic meter.

2.0 RESPONSIBILITIES

2.1 Laboratory Technician

- 2.1.1** It is the responsibility of the laboratory technician to read and perform the operation in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.
- 2.1.2** It is also the responsibility of the laboratory technician to complete all necessary data forms contained within this procedure.

2.2 Laboratory Supervisor

- 2.2.1** It is the responsibility of the laboratory supervisor or designee to ensure that all necessary equipment is available and properly certified.
- 2.2.2** It is the responsibility of the laboratory supervisor or designee to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 REQUIRED MATERIALS

- Analytical balance equipped with a weighing chamber designed to handle unfolded 8" x 10" glass fiber filters and having a sensitivity of 0.1 mg (Sartorius Model 2432 or equivalent) certified within the previous 6 months
- NIST Class "s" weights certified within the previous 12 months
- Clean room gloves to be worn when filters are handled, and to be discarded daily.
- Temperature/humidity recorder Yokogawa μ 100 or equivalent accurate to 1 percent RH and 0.5 °C temperature.
- Certified Hygrometer accurate to 1 percent RH
- Certified thermometer accurate to 0.4 °C
- Equilibration chamber, maintained between 15 °C and 25 °C, ± 3 °C (59.0-78.0 °F ± 5.4 °F average temperature and at a relative humidity between 20.0 and 45.0%)
- Numbering device, capable of printing identification numbers on filters
- Light table
- Personal Computer to enter data
- Ionizing units to be placed inside weighing chamber of balances
- Forms
 - Balance Log Form (Figure 2)
 - Filter Log Form (Figure 3)
 - Unexposed Filter quality Assurance Form (Figure 4)
 - Exposed Filter Quality Assurance Form (Figure 5)

4.0 METHOD

4.1 Calibration of Analytical Balances

The analytical balances are initially calibrated when first purchased and then anytime after the balance is moved. Routine calibrations are performed by an independent agency recommended by the manufacturer every twelve months or whenever the results of daily or weekly checks are unacceptable. The Service/Calibration Record & Certificate of Conformance for each balance should be visibly posted near each analytical balance. The accuracy of the deflection scale on the balance is monitored and controlled using the following procedure:

- 4.1.1** Daily - An NIST class "s" five gram weight is weighed with the balance set at 5.xxxx grams. This checks the lower end of the deflection scale (0.xxxx decimal places). The same weight is then weighed with the balance set at 4.xxxx grams. This

checks the upper end of the deflection scale. A 2 gram NIST class "s" weight is weighed with the balance set at 2.xxxx grams. This checks the low end of the deflection scale. The same weight is then weighed with the balance set at 1.xxxx g. This checks the upper end of the deflection scale.

4.1.2 Weekly - A 2 gram NIST class "s" weight is weighed with the balance set at 2.xxxx grams. This checks the low end of the deflection scale. The same weight is then weighed with the balance set at 1.xxxx g. This checks the upper end of the deflection scale.

4.1.3 Measured weights in 4.1.1 and 4.1.2 must fall within ± 0.5 mg of the true weight. If not, filter weighing for TSP & PM₁₀ are suspended until the balance has been recalibrated.

4.1.4 After every 10 filters, the balance zero is checked. If the zero is found to have drifted by more than 0.3 mg, then the zero is adjusted, then set, and the balance rechecked.

4.1.5 Records of daily and weekly balance checks are kept in the Filter Processing Laboratory Analytical Balance Calibration Data Sheet (Figure 2).

4.2 Relative Humidity Temperature and Indicators

4.2.1 Daily readings verifying proper conditions (20%-45%) for humidity and temperature (59-86°F) are recorded on a log (Figure 3) which is maintained in the filter processing laboratory.

4.3 Filter Selection

Glass filters are used in the collection of Total Suspended Particulates while quartz filters are used for PM₁₀ collection. Filters purchased must meet the following criteria:

- Size $20.3 \pm 0.2 \times 25.4 \pm 0.2$ cm (nominal 8 x 10 in.)
- Nominal exposed area: 406.5 cm² (63 in.²)
- Material: Glass or quartz fiber or other relatively inert, nonhygroscopic material (refer to Tierney, G.P. and W.D. Conner, Hygroscopic Effects on Weight Determinations of Particulates Collected on Glass-Fiber Filters. An. Ind. Hygiene Assoc. J., 28:363, 1967)
- Collection efficiency: 99 percent minimum as measured by the DOP test (ASTM-2986) for particles of 0.3 μ m diameter
- Recommended pressure drop range; 42-54 mm hg (5.6-7.2 K Pa) at a flow rate of 1.5 std m³/min through the nominal exposed area.
- pH: 6 to 10
- Integrity: 2.4 mg maximum weight loss
- Pinholes: none
- Tear Strength: 500 g minimum for 20 mm wide strip cut from filter in weakest dimension (see ASTM Test D828-60)
- Brittleness: no cracks or material separation after single lengthwise crease

These minimum specifications are to be incorporated in all purchase orders of filters for use by the method indicated in this SOP. Additional specifications may be required if the sample is to be chemically analyzed.

4.4 Filter Inspection (Unexposed Filters)

Each filter is visually inspected for pinholes, loose particles, fraying, tears, creases, lumps or other defects. Gloves are worn during the handling of all filters (exposed/unexposed) to eliminate interference from body oils, hygroscopic particles, and static electricity during weighing operations.

4.4.1 Visual Inspection Criteria for Glass & Quartz Fiber Filters for TSP & PM₁₀ Sampling

The following descriptions of visual defects are used in the acceptance inspection of filters. Visual inspections for pinholes and other imperfections are made using a light screen or table. The filters are inspected critically for the following defects:

- Pinhole - a small hole that can be identified by examining both the front and back of the filter. A filter with such a defect is considered a reject filter. (A reject filter is considered unusable.)
- Line - occasionally a fine line created by the manufacturing screen across the filter. A filter with such a defect is considered a defective filter. (A defective filter is considered usable.)
- Thin spot - a small area (slightly larger than pinhole) viewed from the filter back that appears to be weak. More light can be seen through this area than through the surrounding area. Viewed from the front, there is no evidence of this problem. There can be several spots per filter. A filter with such spots is considered defective.
- Dense spot - viewed from the filter back, this appears as a dark area (approximately 1/8"-1/4" in diameter) without sharply defined edges. Viewed from the front, an accumulation of filter fibers can be seen. If there is only one dense spot per filter, and the area covered is less than 1/4" in diameter, the filter will be considered a defective filter. Any filter which contains more than one dense spot shall be considered a reject.
- Dark spot - these spots are distinguished from the dense spots in that such dark spots resemble "fly specks." Their presence results in a defective filter. Any filter containing more than two such dark spots will be considered a reject.
- Loose fiber on filter back - this appears as if a rough object had been moved across the filter back and loosened the filter base. If the number of fibers is small and can be brushed off, the defective filter can be used. If, in EPA's judgement, the fibers are too large or too numerous to remove, the filter will be considered a reject.
- Glass fiber - when viewed from the back, this defect resembles a thin spot. The shape can be circular or oval. When rubbed, the glass may become detached. No evidence of this defect can be seen from the front. If it

becomes detached and creates a pinhole, the filter is a reject. Otherwise, it is only defective, i.e. usable.

- Coloration - yellow, red, or other colored spots. A filter with such colorations is considered a reject.
- Other - a filter with any imperfection not described above, such as frayed edges or indentations or the results of other poor workmanship may in the judgement of EPA be considered defective or reject.

A defective filter is one that contains one or more visual defects not considered reject. Reject filters and defective filters are, therefore, mutually exclusive.

4.5 Filter Identification (Unexposed Filters)

4.5.1 With the aid of a consecutive numbering machine, a 6 digit serial number is assigned to each inspected filter. This number is printed on the side of the manufacturing number or on the smooth side of each filter in the upper right hand corner. Gentle pressure is used to avoid damaging the filter. For quartz filters, the batch number is also stamped on the filter at this time since the filter does not have any manufacturing number.

4.5.2 Filter jackets are also prepared at this time. Computer stickers with the filter serial number are applied to both the white (TSP) & blue (PM₁₀) jackets. The manufacturer's batch number is also marked on the jacket.

4.6 Filter Equilibration

4.6.1 Prior to weighing, both exposed and unexposed filters are set to equilibrate for a minimum of 24 hours in the conditioning room where temperature between 59.0 and 78.0°F and relative humidity between 25.0 and 50.0% are maintained.

4.6.2 Unexposed filters are equilibrated outside the folders while exposed filters are left inside the folders.

4.7 Daily Start-Up

4.7.1 Before weighing the first clean or exposed filter, a balance check is performed using a 2.0g and a 5.0g NIST standard Class "s" weight.

4.7.2 Actual and measured weights are recorded on the Analytical Balance Calibration Data sheet (Figure 2) along with the date and operator's initials. If actual and measured values differ by more than ± 0.5 mg, no weighing can take place until the problem has been corrected.

4.8 Routine Analysis Procedure (Unexposed Filters)

- 4.8.1 Clean filters are processed in lots of 50. Initial weight and date weighed are recorded on each filter jacket. Clean filters are placed in jacket unfolded, numbered side up. When filters pass the Quality Control audit (see Section 5.1), they are sent out to the field.
- 4.8.2 Laboratory technicians are responsible for initial logging of serial numbers, sample dates, site location, and sampler identification numbers on the TSP Filter Log Sheet (Figure 4) upon receipt of exposed filters.

4.9 Routine Analysis Procedure (Exposed Filters)

- 4.9.1 Exposed filters are processed in lots no greater than 50. If samples exceed 50, a second Quality Assurance Sheet is completed. Final weight and date weighed are recorded on each filter jacket. Exposed filters are left inside their jackets to equilibrate.
- 4.9.2 Any collected particles which come loose upon removing the exposed filter from the jacket will be recovered. Insects embedded in the filter are removed with Teflon tipped tweezers (or equivalent) to avoid disturbing the sample.
- 4.9.3 If the number of insects appears greater than 10 or their total weight greater than 5.0 mg (the audit tolerance of exposed filters), it is to be reported to the laboratory supervisor for a decision on whether to accept or reject the sample. All action taken is noted on the filter jacket.
- 4.9.4 Samples are weighed to 0.1 mg and are recorded on the filter jacket.

4.10 Sample Validation

Information required to compute TSP & PM₁₀ concentrations must be recorded on the filter jacket. Any information that is missing and unobtainable upon inquiry to the field technician or the laboratory supervisor will cause the sample to be invalidated.

The following acceptance criteria have been established to assist in the validation of filters.

- 4.10.1 The sampling time must be 1440 ± 60 minutes for a 24 hour sample and must be diurnally consistent.
- 4.10.2 The initial and final flows must be in the range of 39-60 acfm for the General Metals style HI-VOL (TSP). (Consult with project manager when final flow is greater than ± 5.0 acfm of the initial flow.)
- 4.10.3 The initial and final flows should be within ± 4 acfm of the flow controller set flow (FCSP 40.0) for HI-VOLS with size selective head inlets (PM₁₀).
- 4.10.4 The initial and final flows should be within the bounds of the reviewed calibration curve in use.

NOTE: It may not be possible to calibrate the volume control HI-VOLS in the operating range; in this case only, the calibration curve may be extrapolated.

- 4.10.5** Documentation on the filter jacket must be complete and consistent with the corresponding sampler calibration data.
- 4.10.6** The serial number of the filter jacket must be identical to the serial number on the filter.
- 4.10.7** There must be no evidence of leaks on the edges of the exposed area of the filter.
- 4.10.8** There must be no evidence of filter damage due to wildlife damage, bad weather, or due to natural phenomena (Bird damage, excessive insects, or water spots, etc).
- 4.10.9** The filter must be properly aligned, containing the entire sample on the filter.
- 4.10.10** There must be no visible damage to the filter (tears, holes, etc.).
- 4.10.11** Agreement between computer computation and manual calculation must exist.

4.11 Calibration Curves

All calibration curves are received by the filter processing section and are reviewed for the following:

- 4.11.1** Review of the calibration curve data sheets for completeness of identification information (i.e., date, site code, system number, ENSR number, etc.)
- 4.11.2** Ensuring plotted line is a fair representation of all data points.
- 4.11.3** Valid curves are initialed and kept with the appropriate filters.

4.12 Calculations

Accurate reporting of total PM₁₀ mass concentration data requires the calculation of the total standard volume of air sampled (Equation [1]) and the final computation of total PM₁₀ mass concentration (Equation [2]).

- 4.12.1** Calculate the total standard volume of air sampled:

$$V_{std} = (\overline{Q_{std}}) (t) \quad (1)$$

Where:

V_{std} = total volume of air sampled in standard volume units, std.m³

$\overline{Q_{std}}$ = average sampler flow rate corrected to EPA-standard conditions, std.m³/min

t = total elapsed sampling time, min.

4.12.2 Calculate total PM₁₀ mass concentration in µg/std.m³:

$$PM_{10} = (10^6)(W_g - W_t)/V_{std} \quad (2)$$

Where:

PM₁₀ = PM₁₀ mass concentration, µg/std.m³

10⁶ = conversion factor, µg/g

W_g, W_t = gross and tare weights of the HV PM₁₀ filter, respectively, g

V_{std} = total sample volume in standard volume units, std.m³.

4.13 Data Reporting

4.13.1 Data are entered from the filter jacket into the data base via a PC. NO CHANGES ARE MADE TO THE DATA. If errors are found in the information on the filter jacket, then the nature of the error must be clearly established and explained on the filter jacket and in a brief entry in the data base (Figure 5, "Comments" column).

4.13.2 The system stores all data, calculates TSP & PM₁₀, and allows the technician to access the data in report form.

4.13.3 Each invalid sample is assigned a status code (X or Z) according to the following criteria:

X = mechanical failure, surface damage, leakage, invalid flow, etc.

Z = acts of God, (natural phenomena) i.e., snow, rain, bugs, etc.

In addition, data loss statements are provided (when data capture is below client requirements) to facilitate identification of consistent problem areas.

4.13.4 A PARTIC is generated for the client, based on a validated TSP & PM₁₀ report (Figure 6).

The PARTIC consists of a

- Summary Table (TSP listed in chronological order)
- TSP Analysis Summary
- Upon request, an Ordered Rank Table (TSP listed highest to lowest)

The PARTIC report period depends on the particular project requirements (i.e., monthly, quarterly, etc.).

5.0 QUALITY CONTROL PROCEDURE

Three Quality control audit procedures are used:

- 1) Audit of clean filters
- 2) Audit of exposed filters
- 3) Audit of data processing

5.1 Clean Filter Weighing Audits

5.1.1 Weighing audits are performed on filters in batches of 50. Eight out of 50 filters are randomly selected and reweighed. Temperature and humidity as well as date and audit weight are recorded on a Quality Control Sheet. (Figure 7).

5.1.2 If any one of the check weights differs by more than ± 2.8 mg from the original weight, all the filters in the batch must be reweighed. Quality Assurance Data sheets are maintained in the Quality Control notebook.

5.2 Exposed Filter Weighing Audits

5.2.1 In order to allow for possible data corrections, exposed filters should be weighed and audited as soon as possible after a 24-hour conditioning period.

5.2.2 To begin audit, randomly select and reweigh 10% (or 5 filters, whichever is greater) out of every lot of 50 or less. This means 100% checking of lots containing four or fewer filters. All filters in a lot should be reweighed if any audit weight differs more than ± 5.0 mg of the original. Enter all data on a Quality Control sheet for exposed filters. (Figure 8).

5.3 Data Processing Audits

5.3.1 10% of the filters are checked against the validated PARTIC report to ensure that all information on the particulate report is exactly the same as what was originally provided on the corresponding filter jacket. Any changes to this information must be thoroughly explained on the partic report.

5.3.2 In order to perform quality control of the computer computation of TSP values, one value per network/month should be manually determined from a calculator or other source using the equations in Section 4.12. This manual computation is recorded on the filter jacket selected. This value is then compared to the computer hard copy print out. If these two values do not agree within the reasonable rounding deviations, results should be reported to the laboratory supervisor who will decide on an appropriate course of action.

6.0 DOCUMENTATION

Comprehensive documentation of the determination of suspended particulates will be achieved through the completion of the appropriate forms as described in Section 4. These forms include:

- Filter Processing Laboratory Analytical Balance Calibration Data Sheet (Figure 2)
- Temperature and Humidity Log (Figure 3)
- Filter Log Sheet (Figures 4)
- TSP Report (Figures 5-6)
- Quality Assurance Data Sheet for Unexposed High Volume Filters (Figure 7)
- Quality Assurance Data Sheet for Exposed High Volume Filters (Figure 8)

7.0 REFERENCES

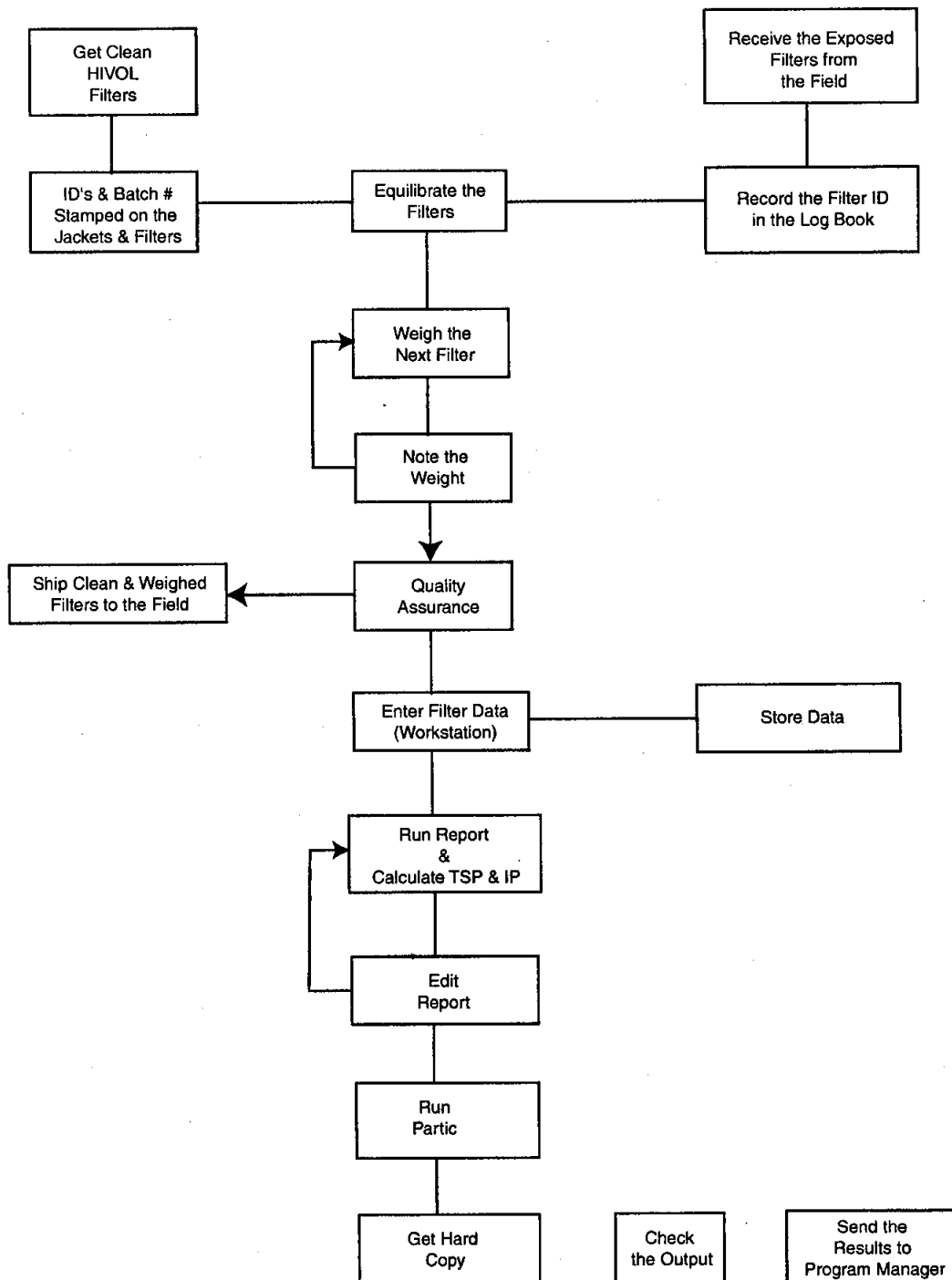
U.S. Environmental Protection Agency. 1994. Quality Assurance Handbook for Air Pollution Measurement Systems Volume II, Section 2.11, EPA-600/R-94/038b, ORD, Washington, DC 20460

Code of Federal Regulations 40 CFR, Part 58, Appendix A, October 2006.

U.S. Environmental Protection Agency. 1997. *Code of Federal Regulations*. Title 40, Chapter I, Subchapter C, Part 50, Appendix M. Washington, DC. Office of the Federal Register.
Reference Method for PM₁₀ Sampling (inhalable particulates). 40 CFR 50, Appendix J.

SOP NUMBER: 2629-201

Figure 1
Filter Processing Procedure



M990319

Figure 2

**FILTER PROCESSING LABORATORY
ANALYTICAL BALANCE CALIBRATION DATA SHEET**

Lab Balance: Month/Year:

Control R.T.: 59 – 78°F Control R.H.: 25% - 50% Control Wgt: X.0000> \pm 0.0005g

DAY	TIME	R.T. (F)	R.H. (%)	BALANCE CHK 0.5000 g*	BALANCE CHK 2.0000 g	BALANCE CHK 5.0000 g	BALANCE CHK 100.0000 g**
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

*Do Not Proceed With Filter Weighting if Chk is >+0.0005 g

**Wgt Calibrations for Method 5 Gravimetric Analysis

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Figure 3

RELATIVE HUMIDITY AND TEMPERATURE QUALITY CONTROL LOG
42 NAGOG PARK LAB

Date	Time	Relative Humidity	Temperature	Humidifier Checked	Initials	Remarks

Relative humidity and temperature should be checked and recorded every 4 hours.
Lab conditions should remain between 59 – 78 degrees F with a relative humidity between 25% - 50%.

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Figure 4

FILTER LOG SHEET

Network: Month: Year: Site Code:

Site Name								Date Recvd	Init
Sampler Serial #									

Day	Filter #	Filter #	Filter #	Filter #	Filter #	Filter #		
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								

SOP NUMBER: 2629-201

Figure 5

TSP REPORT

NETWORK: NETWORK NAME SITE: SITE NAME SITE #:1

DATE
SAMPLED ---TIME--- WEIGHT OBSERV TRUE FLD AVG ---TSP--- F TEMP PRES

02/06/93 FIN 73928.2 4.4774 1.820 43.9 44.0 43.5 1.0 I 25.0 760.
03/04/93
UNIT 1 INIT 72483.2 4.4757 1.770 43.0 42.9 25.0 760.
07/08/92
DELT 1445.0 0.0017 JACKET #:154735 -

BATCH # 105984, CALCURVE:12/22/92, SERIAL # 17549
COMMENT:DICKSON CHART INDICATES A 24HR. SAMPLING TIME(MIDNIGHT - MIDNIGHT)

02/12/93 FIN 75340.7 4.4836 1.830 44.1 44.1 44.0 9.2 I 25.0 760.
03/04/93
UNIT 1 INIT 73928.2 4.4674 1.820 43.9 44.0 25.0 760.
07/08/92
DELT 1412.5 0.0162 JACKET #:154737 -

BATCH # 105984, CALCURVE:12/22/92, SERIAL # 17549
COMMENT:DICKSON CHART INDICATES A 24HR. SAMPLING TIME(MIDNIGHT - MIDNIGHT)

02/18/93 FIN 76755.6 4.3155 1.800 43.5 43.5 43.8 20.8 I 25.0 760.
03/15/93
UNIT 1 INIT 75340.7 4.2789 1.830 44.1 44.1 25.0 760.
11/30/92
DELT 1414.9 0.0366 JACKET #:156649 -

BATCH # 026155, CALCURVE:12/22/92, SERIAL # 17549
COMMENT:DICKSON CHART INDICATES A 24HR. SAMPLE TIME(11:00 PM - 11:00 PM)

02/24/93 FIN 78169.2 4.1240 1.810 43.7 43.5 43.6 13.9 I 25.0 760.
03/15/93
UNIT 1 INIT 76755.6 4.0997 1.800 43.5 43.5 25.0 760.
11/30/92
DELT 1413.6 0.0243 JACKET #:156647 -

BATCH # 026155, CALCURVE:12/22/92, SERIAL # 17549
COMMENT:DICKSON CHART INDICATES A 24HR. SAMPLING TIME (11:00PM - 11:00PM)

M990237

Figure 6

NETWORK NAME - FEBRUARY 1993
Particulate Daily Summary

DATE	SITE NAME TSP UG/M3	SITE NAME CSP UG/M3	SITE NAME IP UG/M3	SITE NAME CIP UG/M3
02/06/93	49.5	48.9	43.4	40.2
02/12/93	--- X	19.8	17.2	16.8
02/18/93	49.8	50.3	29.1	29.2
02/24/93	62.3	56.7	40.2	--- X
A MEAN	53.9	43.9	32.5	28.7
G MEAN	53.6	40.8	30.6	27.0
G S.MEAN	1.1	1.6	1.5	1.6
TOTAL V	4	4	4	4
GOOD V	3	4	4	3
MSG V	1	0	0	1
D CAP %	75.0	100.0	100.0	75.0

A MEAN = ARITHMETIC MEAN
 G MEAN = GEOMETRIC MEAN
 TOTAL V = TOTAL NUMBER OF VALUES
 D CAP % = DATA CAPTURE (PERCENT)
 --- X = SAMPLE DOES NOT MEET VALIDATION CRITERIA
 TSP = TOTAL SUSPENDED PARTICULATES
 CSP = COLLOCATED TSP
 G S.DEV = GEOMETRIC STANDARD DEVIATION
 MSG V = NUMBER OF (--- X) VALUES
 GOOD V = NUMBER OF GOOD VALUES
 IP = INHALABLE PARTICULATES
 CIP = COLLOCATED IP

Run Date:
03/11/93

 * Data Validated by *
 * ENSR Consulting and Engineering *

M990238

SOP NUMBER: 2629-201

Figure 6 (continued)

NETWORK NAME - FEBRUARY 1993

Particulate Analysis Summary

	SITE NAME TSP UG/M3	SITE NAME CSP UG/M3	SITE NAME IP UG/M3	SITE NAME CIP UG/M3
POSSIBLE NUMBER OF READINGS	4	4	4	4
NUMBER OF GOOD VALUES	3	4	4	3
NUMBER OF MISSING VALUES	1	0	0	1
DATA CAPTURE (PERCENT)	75.0	100.0	100.0	75.0
NATIONAL 12-MO STANDARD 1	75	75	50	50
NATIONAL 12-MO STANDARD 2	60	60	50	50
STATE 12-MO STANDARD 1	75	75	50	50
STATE 12-MO STANDARD 2	60	60	50	50
ARITHMETIC MEAN	53.9	43.9	32.5	28.7
GEOMETRIC MEAN	53.6	40.8	30.6	27.0
GEOMETRIC STANDARD DEV	1.1	1.6	1.5	1.6
NATIONAL 24-HR STANDARD 1	260	260	150	150
NUMBER OF EXCEEDANCES	0	0	0	0
NATIONAL 24-HR STANDARD 2	150	150	150	150
NUMBER OF EXCEEDANCES	0	0	0	0
STATE 24-HR STANDARD 1	260	260	150	150
NUMBER OF EXCEEDANCES	0	0	0	0
STATE 24-HR STANDARD 2	150	150	150	150
NUMBER OF EXCEEDANCES	0	0	0	0

M990339

STATE IS: NAME OF STATE
STANDARD 1 IS PRIMARY STANDARD
STANDARD 2 IS SECONDARY STANDARD

Run Date:
03/11/93

* Data Validated by *
* ENSR Consulting and Engineering *

Figure 6 (continued)

NETWORK NAME - FEBRUARY 1993

Ranked Particulate Summary

SITE NAME TSP UG/M3	SITE NAME CSP UG/M3	SITE NAME IP UG/M3	SITE NAME CIP UG/M3
62.3 02/24/93	56.7 02/24/93	43.4 02/06/93	40.2 02/06/93
49.8 02/18/93	50.3 02/18/93	40.2 02/24/93	29.2 02/18/93
49.5 02/06/93	48.9 02/06/93	29.1 02/18/93	16.8 02/12/93
	19.8 02/12/93	17.2 02/12/93	

Run Date:
04/12/93

```
*****
*           Data Validated by           *
*   ENSR Consulting and Engineering   *
*****
```

M990340

QUALITY ASSURANCE DATA SHEET FOR UNEXPOSED HIGH VOLUME FILTERS

Lot Number

Batch Number

Filter Number

to

PRECONDITIONING

PRECONDITIONING							
	Day	Date	Time	R.H. (%)	R.T. (°F)	By	Remarks
Start							
Complete							

GRAVIMETRIC ANALYSIS

Day

Date _____

Time

Relative Humidity

%

Room Temperature

 $(^{\circ}\text{F})$

Balance Zero*	Drift				Rezero		Prior to Filter Number
	+	0	-		Yes	No	
Initial							
1							
2							
3							

Balance Used

By

***Rezero After 10 to 15 Filters**

QUALITY ASSURANCE AUDIT

Day

Date _____

Time

Relative Humidity

%

Room Temperature

(°F)

Balance Used

Initial Zero

[illegible]

****If Δ weight for any audit filters $> \pm 0.0028\text{g}$, then the entire batch should be reweighed.**

Certified for use by

Date _____

1. Filters must be free of pin holes, tears, lumps or creases.
2. Filters must be properly equilibrated (24 hours of R.H. = 25 – 50% and R.T. = 59 – 78°F).
3. Unexposed filters should be processed in batches of 50.
4. Randomly audit eight filters for batches of 50 or less.

Figure 8

ENSR.**QUALITY ASSURANCE DATA SHEET FOR EXPOSED HIGH VOLUME FILTERS**Network Number of Stations Date From Date To Number of Samples **PRECONDITIONING**

	Day	Date	Time	R.H. (%)	R.T. (°F)	By	Remarks
Start							
Complete							

GRAVIMETRIC ANALYSIS

Day Date Time

Relative Humidity % Room Temperature (°F)

Balance Zero*	Drift			Rezero		Prior to Filter Number
	+	0	-	Yes	No	
Initial						
1						
2						
3						

Balance Used By

*Rezero After 10 to 15 Filters

QUALITY ASSURANCE AUDIT

Day Date Time

Relative Humidity % Room Temperature (°F)

Balance Used Initial Zero

Filter Number	Site	Date	Final Weight (g)	Audit Weight (g)	Delta Weight (g)

Data for this network certified for use by Date

1. Randomly select and reweigh four filters out of every 50 or less.
2. If ΔW for any audit filter differs by more than $\pm 0.0050g$, then filters for entire network must be reweighed.
3. Use final weight in audit calculation for TSP.

2629-201\fig-8.doc

SOP NUMBER: 2630-101**Operation and Maintenance of TECO
49 Ozone Analyzer****Date:** 4th Qtr., 1994**Revision Number:** 1**Author:** Tony Sacco**Discipline:** Air Toxics Measurements**1.0 PURPOSE AND APPLICABILITY**

This standard operation procedure (SOP) defines the tasks necessary for the operation and maintenance of the TECO 49 ozone analyzer. This procedure complies with the provisions and requirements of ENSR SOP 2600, Traceability of Standards.

2.0 RESPONSIBILITIES**2.1 Field Technician**

2.1.1 It is the responsibility of the field technician to read and perform the operation in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.

2.1.2 It is also the responsibility of the field technician to document the procedure in the field station log as well as on data forms contained or referred to within this procedure.

2.2 Project Manager

2.2.1 It is the responsibility of the project manager, or designee, to ensure that the operation is performed at the designated frequency and to ensure that all necessary equipment is available and properly certified.

2.2.2 It is the responsibility of the project manager, or designee, to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 REQUIRED MATERIALS

- TECO 49 Instrument Manual
- Digital Multimeter
- For optical cleaning, a non-metallic rod (wooden dowel, plastic rod, etc.); kimwipes or equivalent (tissues)

- ENSR SOP 2600, Traceability of Standards
- ENSR SOP 2600-001, Precision and Level 1 Span Checks
- ENSR SOP 2600-101, Calibration Check or Audit Using a TECO 49 Ozone Transfer Standard
- ENSR SOP 2600-850, Calibration of Strip Chart Recorders

4.0 METHOD

4.1 Weekly Checks

- 4.1.1** Sample Flow - the sample flowmeter (both flowmeters on front panel) should read at least 1 lpm but not more than 3 lpm. Tap the flowmeter lightly, to make sure the float is not stuck and is actually reading the correct value. If sticking of float is observed, the rotameter and optics should be cleaned.
- 4.1.2** Verify the proper operation of the analyzer by observing the Test A, Test B, Test P/T, Test Noise and Test A/B displays.
- 4.1.3** Replace the filter element in the sample line particulate filter.
- 4.1.4** Verify the proper operation of the cooling fan in the TECO 49.

4.2 Every Two Weeks

- 4.2.1** Dynamic Zero/Span Precision Check - Refer to ENSR SOP 2600-001 for the procedures related to zero and precision span checks. Refer to ENSR SOP 2600-101 for instruction on the use of a TECO 49 transfer standard.

- 4.2.2** Analog Span Check

During the Zero/Span/Precision check (4.2.1) monitor the analog output of the TECO 49 with a DVM. If the TECO 49 is operating on the 0-0.5 ppm (= 0-10V) range, the DVM reading should be 20 x the display on the TECO. For TECOs setup with 0-10V - 0-1.0 ppm, the DVM reading should be 10 x the display on the TECO 49.

If these readings are not within tolerance, the D/A conversion is incorrect. Refer to section VII of the TECO 49 manual.

- 4.2.3 The strip chart recorder should indicate the same voltages as the DVM. Adjust the recorder as necessary. Refer to ENSR SOP 2600-850 Calibration of Strip Chart Recorders.
 - 4.2.4 Adjust the ozonator control switch to the designated daily span position and after obtaining a stable reading disengage the internal ozonator and span valve.
 - 4.3 All weekly and bi-weekly checks should be recorded on the Status/Data Assessment Sheet (Figure 1). All operational and periodic checks should also be noted in the Field Station Log.
 - 4.4 Maintenance

Refer to section V of the TECO 49 Manual for detailed instruction on the following maintenance activities.

 - 4.4.1 Cleaning of the Optical Bench

Should be performed when frequencies drop below 70 KHZ. If, following cleaning, the frequencies are still below 70 KHZ, adjust the optical shutters.
 - 4.4.2 Lamp replacement should be accomplished on a yearly basis or as needed.
 - 4.4.3 Temperature and pressure should be checked at least monthly and adjustments made as required.
 - 4.4.4 At least quarterly, the entire pneumatics should be leak checked and appropriate repairs made as required.
 - 4.4.5 The ozone remaining catalytic converter should be changed yearly or the efficiency of the converter must be verified as discussed in section V of the manual.
 - 4.4.6 The digital to analog converter should be checked once per month (test A/B). Any deviation from a straight line indicates a probable lost fit (see troubleshooting section of the manual).
 - 4.5 Before leaving the site, check all listing and mode switches to be certain that the analyzer is left in the proper sampling configuration.

5.0 QUALITY CONTROL

- 5.1** Precision check data sheets should be submitted to the project manager or designee for review. Calibration inputs should be checked using the transfer standard calibration equation.

6.0 DOCUMENTATION

- 6.1** All weekly and bi-weekly checks should be recorded on the Status/Data Assessment Sheet (Figure 1). An operational and periodic checks should also be noted in the Field Station Log.

7.0 REFERENCES

Not applicable.

INSERT STATUS/DATA ASSESSMENT SHEET HERE

SOP NUMBER: 2660-210**Field Calibration Procedure:
Temperature/Delta Temperature
Monitoring System****Date:** 4th Qtr., 1994**Revision Number:** 1**Author:** Tom Sroczynski**Discipline:** Air Toxics Measurements**1.0 PURPOSE AND APPLICABILITY**

- 1.1** This standard operating procedure (SOP) describes the requirements for field calibration of all temperature/delta temperature monitoring systems.
- 1.2** A calibration of any monitoring instrumentation must also include calibration verification of the digital data acquisition system (DAS) and, if applicable, associated strip chart recorder.
- 1.3** The standard method is to detach the aspirator and temperature probe from the tower, lower with the signal cable, or alternately reconnect the probe to signal conditioning on the ground, and place the probe in temperature baths at the tower base or inside the instrumentation shelter.
- 1.4** For newly installed systems, or for assisting in troubleshooting temperature or delta temperature systems, an ice bath tower verification may be performed. This check will confirm the integrity of the entire temperature monitoring system.
- 1.5** This procedure conforms the requirements of ENSR SOP 2400, Traceability of Standards and ENSR SOP 2660, Meteorological Sensor Siting and Calibration.

2.0 RESPONSIBILITIES**2.1 Field Technician**

- 2.1.1** It is the responsibility of the field technician to read and perform the calibration in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.
- 2.1.2** It is also the responsibility of the field technician to document the calibration in the field station log as well as on any data forms contained or referred to within this procedure.

2.2 Project Manager

2.2.1 It is the responsibility of the project manager, or designee, to ensure that the operation is performed at the designated frequency and to ensure that all necessary equipment is available and properly certified.

2.2.2 It is the responsibility of the project manager, or designee, to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 REQUIRED MATERIALS

- 2 Digital volt meters (Fluke 8060A or equivalent) - calibrated within the previous twelve months.
- Temperature reference device - (probe/bridge or thermometers) -10 to +50°C range calibrated within the previous twelve months.
- Crushed ice.
- 1 gallon distilled water.
- Communication devices (required for tower calibration).
- 3 wide mouth thermos bottles.
- Immersion heater or hot pot.
- Voltage Reference Source.
- Temperature/Delta Temperature instruction manual.

4.0 METHOD

4.1 Ground Calibration

4.1.1 "DOWN" the appropriate channel of the DAS to isolate calibration activities from ambient data collection. Mark the back-up strip chart recorder, if applicable, with the date, time and your initials.

4.1.2 For the calibration of delta temperature systems, all the delta temperature probes must be placed in the same baths together.

- 4.1.3 Crush enough ice to fill a thermos approximately half way. Fill the rest of the thermos with distilled water. Place the probe and the temperature reference device in the ice bath (32oF). Stirring constantly, allow the bath to stabilize for 5 to 10 minutes. Record the DAS output, translator output, the reference bath temperature and the strip chart recorder reading as "Initial" on the Temperature/Delta Temperature Calibration data sheet (Figure 1).

NOTE:If platinum resistance thermometers are under test, also record the bridge outputs in addition to the above information.

- 4.1.4 Place the probe and the temperature reference device in the hot bath (120oF). Stirring constantly, allow the bath to stabilize for 5 to 10 minutes. Record the DAS output, translator output, the reference bath temperature and the strip chart recorder reading as "Initial" on the calibration data sheet.

NOTE:The hot bath temperature will drift down at a steady rate. Cover the thermos, if possible, and be sure to take instantaneous readings from the reference device, the DAS and translator.

- 4.1.5 Place the probe and the temperature reference device in the ambient bath (70°F). Stirring constantly, allow the bath to stabilize for 5 to 10 minutes. Record the DAS output, translator output, the reference bath temperature and the strip chart recorder reading as "Initial" on the calibration form.

- 4.1.6 For temperature monitoring systems, the DAS readings for each of the calibration challenges should agree with the reference device temperatures within +/- 0.3°C/0.6°F.

- 4.1.7 Since all the delta temperature probes are challenged in the same baths together, true delta temperature should be 0.00. The tolerance for delta temperature systems is 0.10°C/0.18°F.

- 4.1.8 If the DAS readings do not agree with the reference device within the tolerances listed above, place the translator in the zero mode and adjust the temperature card or delta temperature card zero pots as necessary to 0.00 volts +/-0.01 vdc. The DAS should then read the zero value within the tolerances listed in 4.2.6 or 4.1.7.

- 4.1.9** Place the translator in the span mode and adjust the temperature card or delta temperature card span pot as necessary to 10.00 volts +/- 0.01 vdc. The DAS should then read the full scale value within the tolerances listed in 4.1.6 or 4.1.7.
- 4.1.10** Repeat steps 4.1.3 through 4.1.9 and verify that all readings are within tolerance of the reference temperatures in each of the three baths. Record the results as "Final" on the calibration data sheet.
- 4.1.11** If, following zero and span adjustment, the temperatures still do not fall within tolerance when checked in the temperature baths, replace the translator card, calibrate as above, and record the results as "Final" on the calibration data sheet. The translator card which was removed should be returned to the manufacturer for repair.
- 4.1.12** Reassemble the system. Compare the ambient reference to tower readings to verify that system readings appear reasonable
- 4.1.13** "UP" the appropriate channel of the DAS to resume collection of ambient data. Mark the strip chart "end calibration", note the time and initialize the chart.

4.2 Tower Calibration Verification (Optional)

A tower ice bath verification may be performed on new systems to confirm the integrity of the entire temperature monitoring system, or as a troubleshooting aid.

- 4.2.1** Prepare the ice baths. For best results use crushed ice and distilled water for the ice bath.
- 4.2.2** The tower persons position themselves at the sensor levels and remove the probe(s) from the radiation shields after communication between tower and ground person is established.
- 4.2.3** The ground person positions himself at the signal conditioning location and is ready to monitor translator output voltages, recorder and digital data indications.
- 4.2.4** The ice bath temperature is verified prior to tower climb.

- 4.2.5 The tower person places all probes in the ice bath and stirs the bath for two to five minutes or until the probes have come to thermal equilibrium with the bath.
- 4.2.6 Upon command from the ground person, the tower person calls out the ice bath temperatures which the ground person logs along with the translator outputs, recorder and DAS readings.
- 4.2.7 Once acceptable results are obtained, use an average of the good data "Runs". Record the temperature and delta temperature translator output voltages, tower bath temperatures, recorder and DAS readings on the Temperature/Delta Temperature Calibration Form (Figure 1).
- 4.2.8 Note that a well stirred distilled ice bath will be $0^{\circ} \pm 0.02^{\circ}\text{C}$ and that all system indications can be recorded sequentially without repeated checks of the bath temperatures as long as the probes under test have had sufficient time to stabilize.

4.3 Aspirator Check

- 4.3.1 Connect the voltmeter in series with the AC hot wire to the aspirator motor and set the voltmeter to measure AC current. Energize the motor and record the motor current. The specifications for each manufacturer are listed as follows:

Line voltage = Climet 0.11 ± 0.02 amps
115 VAC $\pm 10\%$ MRI 0.26 ± 0.05 amps
at 60HCZ T-G 0.65 ± 0.10 amps
Climatronics 0.20 ± 0.04 amps
RM Young 0.11 ± 0.02 amps
- 4.3.2 If the aspirator is equipped with an airflow switch then verify proper operation.
- 4.3.3 Inspect the aspirator intake and shield area for mechanical damage, foreign material, or any other abnormal conditions and correct as required.
- 4.3.4 With the motor running verify that the fan is sucking air through the intake, and exhausting the air out of the motor housing.

- 4.3.5 Perform any additional scheduled maintenance per the manufacturer's manual.

5.0 QUALITY CONTROL

- 5.1 Temperature monitoring systems must always be left operating within $\pm 0.3^{\circ}\text{C}/0.6^{\circ}\text{F}$ of the reference device in each temperature bath (ice, ambient and hot).
- 5.2 Delta temperature monitoring systems must always be left operating within $\pm 0.1^{\circ}\text{C}/0.18^{\circ}\text{F}$ of zero in each temperature bath (ice, ambient and hot).
- 5.3 As soon as possible following calibration, the completed calibration form should be submitted to the project manager, or designee, for review. Calculations are to be reviewed for accuracy. Standards and test equipment are to be reviewed for traceability and completeness. DAS and strip chart readings are to be reviewed for agreement and completeness.

6.0 DOCUMENTATION

- 6.1 All calibration data is to be recorded onto the Temperature/Delta Temperature data sheet (Figure 1). This form must be completed and delivered to the project manager, or designee, for review. A copy of the form must be maintained in the shelter.
- 6.2 All activities performed in the shelter must be documented in the Field Station Log, including date, the time in and out, technician initials and employee number, activities performed, the time the sensor is taken off-line and then put back in service, calibration results as well as any other circumstances which may arise during the site visit.
- 6.3 In addition, if there is a strip chart recorder associated with the analyzer, the following information must be noted on the strip chart:
- date
 - employees initials and employee number,
 - time off and back on-line,
 - reason for taking instrument off-line, and
 - an explanation of each significant deflection of the pen.

7.0 REFERENCES

Appropriate manufacturer's instruction manual.

SOP NUMBER: 2900-001**Performance Audits of Air Quality
Monitors****Date:** 1st Qtr., 2007**Revision Number:** 4**Author:** Vincent Scheetz**Discipline:** Air Measurements**1.0 PURPOSE AND APPLICABILITY**

- 1.1** This procedure describes the methods and considerations applicable in conducting performance audits of air quality monitoring equipment. This procedure complies with and is to be used in conjunction with ENSR SOP 2900, Field Audit of Air Monitoring Instrumentation.
- 1.2** All standards (i.e., gas cylinders, flow meters, flow controllers, U.V. photometers, orifices) must be traceable to National Institute of Standards and Technology (NIST).
- 1.3** The auditor must be a person uninvolved in the operation and calibration of the analyzers to be audited. Audit standards must be different from those used to calibrate the audited analyzers.

2.0 RESPONSIBILITIES**2.1 Auditor**

- 2.1.1** It is the responsibility of the field auditor to read and perform the audit in accordance with the methods and requirements specified in this and all referenced ENSR Standard Operating Procedures.
- 2.1.2** It is the responsibility of the auditor to document the procedure on strip chart recorders, in the field station log, as well as on any data forms contained within this procedure.
- 2.1.3** It is also the responsibility of the auditor to inform the project manager of the preliminary performance audit results and systems audit findings as soon as they are available. The auditor should inform the project manager of any out of tolerance conditions preferably before leaving the monitoring site.

2.2 Quality Assurance

2.2.1 It is the responsibility of Quality Assurance to ensure that the audit is performed in accordance with this and all referenced ENSR SOPs, at the designated frequency and that the audit satisfies the requirements of the program (ie, PSD).

2.2.2 It is the responsibility of Quality Assurance to generate and distribute the audit report presenting performance audit results, accuracy statistics and systems audit findings. Quality Assurance must also ensure that all applicable documentation is reviewed for accuracy and completeness, is reviewed in a timely manner and to inform the project manager should an error be discovered.

2.3 Project Manager

2.3.1 It is the responsibility of the project manager to schedule calibrations or other corrective action necessary to rectify any audit finding.

2.3.2 It is the responsibility of the project manager to forward copies of the audit report to the client.

3.0 REQUIRED MATERIALS

ENSR SOP 2600, Field Calibration Control Plan

ENSR SOP 2900, Field Audit of Air Monitoring Instrumentation

ENSR SOP 2600-101, Calibration Check or Audit Using a TECO 49 Ozone Transfer Standard

ENSR SOP 2600-700, Operation of the ENSR Portable Field Calibration System

Equipment and standards as necessary

- A calibrated HI-VOL calibration orifice with associated calibration data, adaptor plate, and water manometer. The orifice must have been calibrated within the previous 12 months.
- A calibration system such as an ENSR Gascal 82, TECO 49 or equivalent, capable of producing NIST-traceable concentrations of the appropriate gases, over the full operating range of the analyzers to be audited; at flowrates at least 20% greater than the sample flowrates of the analyzers to be audited. The calibration systems must have been calibrated within the previous three months.

- Materials listed in ENSR SOP 2600-700, plus a digital voltmeter, calibrated within the previous 12 months.

4.0 METHOD

4.1 Analyzer Readings

4.1.1 In all cases, analyzer readings should be taken and recorded on the appropriate data forms as follows:

- From the data acquisition system (DAS). Use the DAS terminal to reconfigure the DAS such that audit challenges are excluded from the valid ambient data base. System responses should be retrieved as five minute average readings. If five minute averages are not available, instantaneous voltage readings are to be recorded and converted to ppm once a stable response is observed. A response is considered stable when there has not been more than a 1.0% change over five minutes.
- From the strip chart recorder. Mark the recorder pen trace with "input" and "analyzer response" for each deflection of the pen. Read the strip chart trace as percent of full scale and record in the appropriate spaces of the calibration data sheet.
- With a DVM, connected to the appropriate data acquisition system leads on the analyzer. DVM readings are only recorded when there is no digital data acquisition system or when there is no DAS channel designated for a particular parameter (such as NO).

4.1.2 In computing delta percent ($\Delta\%$), use the DAS readings to determine PPM response. Use the strip chart readings to determine PPM response when auditing networks with only strip chart data retrieval. Voltmeter readings are only used as a troubleshooting implement and are not used to determine $\Delta\%$ (Equation 1).

$$\Delta\% = \frac{PPM \text{ response} - PPM \text{ input}}{PPM \text{ input}} \times 100 \quad (1)$$

4.2 Gas Dilution

4.2.1 The ideal situation would be to allow the gas dilution system to warm up overnight. If this is not possible, turn on the gas dilution system and allow it to warm up for at least 30 minutes.

4.2.2 Set up the clean air unit (or clean air cylinder) and the gas dilution system, and start clean air passing through the air mass flow controller (or mass flow meter).

NOTE: The clean air unit should be set up to pull outside air. Extend a line from the clean air unit air intake outside the shelter door. Do not attach the clean air intake to the sample manifold.

4.2.3 Disconnect the sample line of the first analyzer to be audited from the sample manifold, and attach it to one port on a fluoroware vent union tee. Attach 4-5 feet of teflon tubing to the outlet port on the audit calibrator and to a branch on the fluoroware tee perpendicular to the analyzer's sample line. Attach one foot or more of teflon tubing to the remaining branch of the tee as a vent. Cap any unused manifold ports to prevent other analyzers from sampling shelter air during the audit.

4.2.4 Reconfigure the DAS such that the audit challenges are excluded from the valid ambient data base. Mark the strip chart (in ink) with a line pointing to the position of the pen at the time when the sample line was removed from the manifold and note the date, local standard time, your initials and employee number and the fact that ambient monitoring has been interrupted for an audit.

4.2.5 Fill out all heading information on the Gas Dilution Audit form (Figure 1) for dilution audits.

NOTE: Be sure to identify all audit standards and test equipment by serial number, calibration date and concentration (if applicable).

4.2.6 Audit gas challenges must be within the following ranges:

for SO ₂ , NO ₂ , O ₃ :	0.80-0.90	*
	0.35-0.45	
	0.15-0.20	
	0.03-0.08	
	zero	

tightening the delivery line on the dilution system to purge the delivery line.

g. If at any time, the regulator is de-pressurized, the purge procedure must be repeated.

4.2.10 After obtaining a stable zero response from the analyzer, continue the audit with the highest concentration, and finish with the lowest. Allow approximately 20 minutes for the analyzer response to stabilize to each audit challenge.

4.2.11 Following the audit, reconfigure the DAS to begin collecting ambient data, mark strip chart "end of audit", initials, date and time and note in the station log audit results, the time the channels were taken offline and then put back on line and any unusual circumstances which may have occurred during that audit.

4.3 NO/NO_x Zero Point

The purpose of this check is to challenge the NO_x system with known inputs that correspond to ambient conditions when little or no NO_x is present. Input of 0.000 ppm should be generated.

4.3.1 Verify the gas and dilution settings by confirming the gas and dilution settings on the audit device. Record the gas and dilution flow rates (both engineering units and meter setting) on the audit form.

4.3.2 Since there is no NO gas being input through the analyzer, the NO_x, nitrogen dioxide (NO₂), and NO input concentrations are 0.000 ppm. Enter the input concentrations on the audit form.

4.3.3 Allow the analyzer sufficient time to sample. When the trace on the strip chart indicates a stabilized response, record the output concentrations of NO_x, NO₂, and NO measured by the analyzer on the audit form under the appropriate column.

4.3.4 Determine the bias between the input concentration and the DAS response. Enter the bias for each parameter on the audit form.

4.4 NO/NO_x Multi-Point Checks

The purpose of these checks are to challenge the NO_x system with known inputs of varying concentrations between 10 and 90 percent of full scale.

4.4.1 Set the gas flowrate to achieve an input concentration of NO = 0.090 ppm (18%) by turning the thumbwheel switch located on the audit device.

4.4.2 Verify the gas and dilution settings by confirming the gas and dilution settings on the audit device. Record the gas and dilution flow rates (both engineering units and meter settings) on the audit form.

4.4.3 Record the input concentration of NO on the audit form. If the gas cylinder certificate indicates an NO₂ impurity concentration, calculate the NO₂

concentration in the audit gas using Equation 2-11 in EPA document *Quality Assurance Handbook for Air Pollution Measurements, Volume II: Ambient Air Specific Methods*. The NO_x input concentration will be equal to the NO + NO₂ input concentrations. Enter the NO_x, NO₂, and NO input concentrations on the audit form.

- 4.4.4** Allow the analyzer sufficient time to sample the audit gas. When the trace on the strip chart indicates a stabilized response, record the output concentrations of NO_x, NO₂, and NO measured by the analyzer in the appropriate column on the audit form. Calculate the delta percent between the DAS response and input concentrations using the equation 4:

$$\Delta\% = \left(\frac{\text{DAS response} - \text{input}}{\text{input}} \right) \times 100 \quad (4)$$

Enter the delta percent values for NO_x and NO under the appropriate Percent Difference column on the audit form.

- 4.4.5** Generate two more NO/NO_x points at approximately 40 and 90 percent of full scale following the procedures outlined above for each point. The gas flow rate should be adjusted to achieve input concentrations of NO equal to 0.200 ppm (40%) and 0.450 ppm (90%).

4.5 Generating NO₂ via GPT

The purpose of this check is to convert a percentage of NO to NO₂ by Gas Phase Titration. This is accomplished by introducing ozone into the audit gas stream, which reacts with the audit NO gas to produce NO₂.

- 4.5.1** Before generating the NO₂ data, determine the calibration relationships (linear regression) of NO and NO_x using the data collected in Sections 3.3 and 3.4. The slope and intercept of the NO data will be used to determine the NO₂ input. The slope and intercept of the NO_x data will be used to determine the amount of NO₂ that is converted to NO. Record the linear regression results on the audit form.
- 4.5.2** While maintaining the audit input NO concentration at 0.450 ppm, activate the ozonator on the audit device and adjust the amount of O₃ used for the reaction. Adjust the setting to convert approximately 80 percent of the input NO gas to NO₂.

Note: The input concentration of NO₂ is determined after the NO₂ response has stabilized.

Record the O₂, gas, and dilution settings on the audit form.

4.5.3 Allow the analyzer sufficient time to sample the audit gas. When the trace on the strip chart indicates a stabilized response, record the output concentrations of NO_x, NO₂, and NO measured by the analyzer under the appropriate column on the audit form.

4.5.4 To calculate the designated NO₂ input concentration, follow the procedure outlined in Section 2.4.3 of the EPA document *Quality Assurance Handbook for Air Pollution Measurements, Volume II: Ambient Air Specific Methods* and Appendix 15, Section 3 of *Volume II, Part 1*.

Note: The NO_x input concentration will be equal to the input concentration from the NO_x span check for the remainder of the GPT check if the gas and dilution settings were not changed since the span check.

4.5.5 Calculate the delta percent of the NO₂ channel following the procedure in Section 3.4.4 and record the results in the appropriate column on the audit form.

4.5.6 Continue the audit by generating two more NO₂ points by converting approximately 40 and 80 percent of NO, respectively. Follow the procedures outlined above for each point.

4.6 Converter Efficiency

This calculation is used to determine how efficiently the catalytic converter performs the NO₂ to NO conversion.

4.6.1 Determine the amount of NO₂ converted to NO by following the outline in Section 2.3.2 of EPA.

The converter efficiency is defined as the slope of the NO₂ (converted) to the NO₂ (input) line multiplied by 100.

4.6.2 The converter is assumed to be within tolerance if the converter efficiency is $\geq 96.0\%$.

4.7 Data Acquisition System

4.7.1 System responses to audit inputs should be retrieved as five minute averages from the DAS. As such, the proper operation of the DAS is verified and documented as part of the audit.

4.7.2 Following stabilization of the analyzer response to the audit input, five minute average readings should be observed until two successive responses agree within two or three ppb of each other. A column on the

data form should be labeled "DAS" in which DAS responses should be recorded as well as noted on the strip chart recorder.

- 4.7.3 DAS responses to calibration inputs should be compared to analyzer analog output as observed with a calibrated digital voltmeter to verify agreement between the analyzer output and the value reported by the DAS. The DAS and analyzer output should agree within ± 0.002 volts.

4.8 Strip Chart Recorder

- 4.8.1 DAS responses to audit inputs are to be noted on the strip chart recorder. The notations on the strip chart recorder should explain each significant deflection of the recorder pen, audit date and beginning and ending times as well as the auditor's initials and employee number.
- 4.8.2 A column on the audit data sheet should be labeled "Strip Chart Recorder" and strip chart readings should be recorded in this column expressed as percent full scale.
- 4.8.3 Following stabilization of the analyzer response to the audit input, the strip chart recorder readings must agree with the DAS within $\pm 1.0\%$.

4.9 Standards Comparison

- 4.9.1 The network portable calibration standard (dilution system and gas standard) should be compared to the audit calibrator for all parameters which are continuously monitored in the network. Use the calibration data for each network calibration standard to generate two concentrations equal to the highest and lowest audit input concentrations. Enter these settings and concentrations in the In-station calibrator verification section in the lower left-hand corner of forms Figures 1, 2 or 3. Obtain an analyzer response at each of the network calibration standard settings and compare them to the analyzer responses to the same input concentrations from the audit calibrator. Compare the NO channel response for NO₂ analyzers.
- 4.9.2 A comparison of the network transfer standard for ozone should be conducted by direct input of known (corrected) concentrations of ozone produced by the audit device into the network transfer standard for measurement. The network transfer standard display should be corrected using the calibration data included with the instrument. The corrected audit device input and corrected network transfer standard response should be compared to determine percent difference.

4.10 U.V. Photometer

Refer to ENSR SOP 2600-100, Calibration Check or Audit using a Dasibi 1003 PC or 1003 RS or ENSR SOP 2600-101, Calibration Check or Audit using a TECO 49 Ozone Transfer Standard. Record all data on the O3-UV Photometer Calibration form (Figure 3).

4.11 In-Station Calibrator Check (Optional)

Activate SPAN mode on the calibration controller, for the analyzer you have just finished auditing.

- 4.11.1 Metronics 230 - In the in-station calibrator documentation, find a calibration curve for the rotameter, and a Laboratory Verification form that gives the permeation rate. Determine flow settings required to reproduce two of the audit concentrations with the in-station calibrator (preferably the highest and lowest audit concentrations). Enter these settings, flows and concentrations in the lower left-hand corner of forms Figures 1, 2, or 3. Obtain an analyzer response at each of the in-station calibrator flow settings. Compare the analyzer responses to the same concentrations from audit calibrator and in-station calibrator. Be sure to return the in-station calibrator to designated settings.
- 4.11.2 ML 8500 - In the in-station calibrator documentation, find a curve of flow setting vs. ppm output. Find the flow settings required to reproduce two of the audit concentrations (preferably the highest and lowest) with the in-station calibrator. Fill out the in-station calibrator verification section of the form (lower left hand corner). Compare the analyzer responses to the same concentrations from the audit calibrator and in-station calibrator. Be sure to return the in-station calibrator to designated settings.
- 4.11.3 Return the calibration controller to MONITOR, and return the analyzer sample line to the manifold.

4.12 HI-VOLS

4.12.1 Transport the following equipment to the monitoring site:

- Audit orifice transfer standard with calibration relationship in actual volumetric flow-rate (Qa) units and traceable to NIST. The audit orifice transfer standard's faceplate or filter cassette may require modification to ensure a good seal during the performance audit. The audit orifice transfer standard should not be the same one that is used for routine calibrations and QC flow checks.
- An associated water or oil manometer, with a 0- to 400-mm (0- to 16-in.) range and minimum scale division of 2 mm (0.1 in.).
- A thermometer capable of accurately measuring ambient air temperatures over a range of 0 to 50 °C to the nearest 0.1 °C. This

- thermometer should be traceable with an accuracy of 0.1 °C to a NIST-certified thermometer or an ASTM thermometer.
- A portable aneroid barometer (e.g., a climber's or engineer's altimeter), capable of accurately measuring ambient barometric pressure over the range of approximately 500 to 800 mm Hg (66 to 106 kPa) to the nearest millimeter Hg and referenced within ± 5 mm Hg of a barometer of known accuracy at least annually.
 - VFC Sampler Audit Data Sheet.
 - A clean filter.

Note: The site operator is responsible for providing the manometer (or other pressure measuring device) that is normally used for measuring the sampler's stagnation pressure, the sampler lookup table or alternative calibration relationship that is currently in effect for determining the flow rate for sampling periods, and any other information or equipment that is normally used to determine the sampler's indicated flow rate.

- 4.12.2 Ensure that the audit orifice has been calibrated within the past year; that the lookup table is current and is the proper document for the device being used. Connect a 8" water or unity oil manometer to the calibrated orifice. The flexible tube which connects the orifice and manometer must be tight at both ends, must be free of holes and the manometer must be held in a vertical orientation.
- 4.12.3 Fill in the appropriate spaces on the Particulate Sampler Audit form (Figure 5). Obtain the seasonal average temperature (T_2) and site mean pressure (P_2) from the most recent calibration curve for the audited sampler.
- 4.12.4 Determine the present ambient temperature (T_1) and barometric pressure (P_1).
- 4.12.5 Install a clean filter in the VFC sampler. A filter cassette may be used if the audit orifice transfer standard can be properly mounted on top of the cassette. Otherwise, install the filter without the cassette. An audit filter should never be used for subsequent sampling because particles $>10 \mu\text{m}$ can be collected on the filter while the inlet is raised. The sample mass will be biased as a result of using a filter for both an audit and subsequent sampling.
- 4.12.6 Install the audit orifice transfer standard's faceplate on the sampler. Check that the gaskets are in good condition and have not deteriorated.
- 4.12.7 Install the audit orifice transfer standard.
- 4.12.8 Leak-test the audit system; identify and correct any leaks before proceeding.
- 4.12.9 Inspect the audit manometer connecting tubing for crimps or cracks. Fully open the valves and blow gently through the tubing, watching for the free flow of the fluid. Adjust the manometer sliding scale so that the zero line is

at the bottom of the meniscuses. Connect the audit manometer to the pressure port on the audit orifice transfer standard. Make sure the unconnected side of the manometer is open to the atmosphere. Make sure that the tubing fits snugly on the pressure port and on the manometer.

4.12.10 Read and record the following parameters on the VFC Sampler Audit Data Sheet:

- Sampler location, date, time
- Sampler model and S/N
- Ambient temperature (T_a), °C and K ($K = °C + 273$)
- Ambient barometric pressure (P_a), mm Hg (or kPa)
- Unusual weather conditions
- Audit orifice transfer standard's S/N and calibration relationship
- Sampler lookup table number or other calibration relationship currently in effect.

4.12.11 Turn on the sampler and allow it to warm up to operating temperature (3 to 5 min).

Note: The sampler inlet may be partially lowered over the audit orifice transfer standard to act as a draft shield (if a shield is not otherwise provided). Use a block to provide at least 2 in. of clearance at the bottom for air flow and for the manometer tubing.

4.12.12 When the sampler has warmed up to operating temperature, observe the pressure drop across the orifice by reading the total manometer deflection and record as ΔH_2O on the audit data sheet.

4.12.13 Instruct the operator to measure the sampler's relative stagnation pressure (i.e., relative to atmospheric pressure) with the manometer (or other pressure measurement instrument) normally used to measure stagnation pressure. Record the relative stagnation pressure as ΔP_{stg} on the data sheet. If ΔP_{stg} is measured in inches of water, convert the reading to millimeters Hg using Equation (5):

$$mm\ Hg = 25.4\ (in.\ H_2O)/13.6 \quad (5)$$

4.12.14 Compute the absolute stagnation pressure, P_1 , as:

$$P_1 = P_a - \Delta P_{stg} \quad (6)$$

and the absolute stagnation pressure ratio as:

$$\text{Stagnation pressure ratio} = P_1/P_a \quad (7)$$

Record the P_1/P_a ratio on the audit data sheet.

4.12.15 Determine the flow rate through the audit orifice transfer standard, Q_a (audit), using Equation (8):

$$Q_a (\text{audit}) = \{[\Delta H_2O(T_a/P_a)]^{1/2} - b\} \{1/m\} \quad (8)$$

where:

Q_a (audit) = actual volumetric flow rate indicated by the audit orifice, m^3/min ;
 ΔH_2O = pressure drop across the orifice, mm (or in.) H_2O ;
 T_a = ambient temperature K ($K = ^\circ\text{C} + 273$);
 P_a = ambient barometric pressure, mm Hg (or kPa);
 b = intercept of the audit orifice transfer standard's calibration relationship; and
 m = slope of the audit orifice transfer standard's calibration relationship.

- 4.12.16** Instruct the operator to determine the sampler's indicated flow rate, Q_a (sampler), using the P_1/P_a value obtained in Step 7 and the sampler's lookup table or alternative calibration relationship. Record this flow rate on the audit data sheet.
- 4.12.17** Calculate the audit flow rate percentage difference between the sampler's indicated flow rate, Q_a (sampler), and the corresponding audit flow rate, Q_a (audit), determined from the audit orifice transfer standard as:

$$\text{Audit flow rate \% difference} = [100] X \{ [Q_a (\text{sampler}) - Q_a (\text{audit})] / Q_a (\text{audit}) \} \quad (9)$$

For the moment, this value should be considered as tentative. Record this value on the audit data sheet.

- 4.12.18** If the audit flow rate percentage difference is within ± 10 , the value may be considered as firm and may be recorded on Part 1 of the audit data sheet.
- 4.12.19** Turn off the sampler and remove the audit orifice transfer standard. If the audit flow rate percent difference is not within 10%, a 3-point audit will be conducted following the guidance in the EPA QA handbook, Section 2..1.7.2, steps 23-32. Otherwise, the 1-point audit procedure will continue to be followed as described in sections 4.12.20-4.12.25 of this SOP.
- 4.12.20** With a filter installed on the sampler in the normal sampling configuration (i.e., with a filter cassette, if normally used), turn on the sampler and allow it to warm up to operating temperature.
- 4.12.21** Measure the sampler's relative stagnation pressure, ΔP_{stg} , and calculate the absolute stagnation pressure ratio, P_1/P_a . Record these data on Part 1 of the audit data sheet. Turn off the sampler and replace the vacuum cap on the stagnation pressure port.
- 4.12.22** Calculate the sampler's indicated operational flow rate, Q_a (sampler), using the P_1/P_a value obtained and the sampler's lookup table or alternative

calibration relationship. Record this flow rate on Part 1 of the audit data sheet.

4.12.23 Calculate the corrected sampler flow rate using Equation (10):

$$Q_a (\text{corrected sampler}) = [Q_a (\text{sampler})] \times [(100 - \text{audit \% difference})/100] \quad (10)$$

where Q_a (sampler) is obtained from above, and the audit flow rate percentage difference is obtained as in equation 9 above. Record this value on Part 1 of the audit data sheet.

4.12.24 Calculate the design flow rate percentage difference between the corrected sampler flow rate from equation 10 and the inlet design flow rate of 1.13 m³/min as:

$$\text{Design flow rate \% difference} = [100] \times [(Q_a (\text{corrected sampler}) - 1.13)/1.13] \quad (11)$$

4.12.25 If the design flow rate percentage difference is within ± 10 percent, the sampler calibration is acceptable. Differences exceeding ± 10 percent should be investigated and may result in the invalidation of all data obtained subsequent to the last calibration or valid flow check. Before invalidating any data, double-check the audit orifice transfer standard's certification, and all calculations. This completes the one-point audit. Return the sampler to its normal operating configuration.

4.13 Systems Audit

4.13.1 Following the performance audit, conduct a systems audit as described in ENSR SOP 2900, Field Audit of Air Monitoring Instrumentation.

4.14 Packing Equipment

4.14.1 General

- Pack equipment in reusable shipping containers whenever possible.
- When unpacking equipment in the field, keep all packing material.
- Wrap all equipment in plastic bags before packing it in styrofoam.

- Pack equipment tightly, so that it is shock-resistant and impact-resistant.
- When using cardboard boxes, tape thoroughly with strapping tape. Be sure to reinforce the corners.

4.15 Shipping Equipment in the Field

4.15.1 Gas Cylinders

- In order to ship gas cylinders by air freight, it will always be necessary to fill out a Restricted Articles (R.A.) form (see Figure 6).
- Always bring the cylinders to the shipper and fill out the R.A. forms there. Different shippers and different offices of any given shipper will often have their own specific requirements as to how the R.A. form should be filled out. The guidance presented in Figure 6 applies to shipping non-flammable gases according to IATA regulations as of 5/93.
- Gas concentrations should be given as percent on these forms. To determine percent from ppm, just divide the ppm value by ten thousand.

e.g.: SO_2 or NO (50 ppm) = $50/10,000\% = 0.005\% = 1\%$

CO (1000 ppm) = $1000/10,000\% = 0.1\% = 1\%$

CO_2 (350 ppm) = $350/10,000\% = 0.035\% = 1\%$

However, it is only necessary to state that the concentration is less than 1.0%

Also state the balance. (e.g., 1% Sulfur Dioxide and 1% Carbon Dioxide, Air Balance; or 1% Nitric Oxide, Nitrogen Balance).

- Be sure you know the approximate pressure in the cylinder. The column on the R.A. form headed "Net Quantity Per Package" is for the amount of gas in each cylinder, in grams. Use the table below to determine the quantity in grams from the approximate pressure.

PSIG	GRAMS
2000 – 2500	1200
1500 – 2000	1000
1000 - 1500	750

500 - 1000
500

500
250

- "Name and full address of Shipper" = enter ENSR, with the address of your office.
- "Name and title of person signing Certification" = enter your name and title.

4.15.2 General

- Review all waybills to make sure the origins and destinations are correct before leaving everything in the hands of the shipper.
- Make sure a waybill has been filled out for every package to be shipped.

5.0 QUALITY CONTROL

- 5.1** Ambient air quality instrumentation responses must agree with the audit standard challenges within +/- 10.0%.
- 5.2** Particulate sampler indicated flows must agree with the audit determined flows within +/- 7.0%.
- 5.3** Data acquisition system responses must agree with the analyzer analog output as read with a calibrated digital voltmeter within +/- 0.002 volts.
- 5.4** Strip chart recorder responses to audit challenges must agree with the system responses as determined from the data acquisition system within +/- 1.0%.
- 5.5** Analyzer responses to two identical network standard and audit standard inputs must agree within +/- 10.0%.

6.0 DOCUMENTATION

- 6.1** Leave copies of the completed audit data sheets at the site. If you do not have extra copies enter a summary of average % by parameter in the logs.
- 6.2** The log sheets should contain a brief chronology of your actions.

- 6.3 Every significant deflection of the recorder pens during your visit should be labeled.
- 6.4 Strip charts should be labeled with the date, the auditor's initials and employee number, and the audit start and end time.
- 6.5 Notify the project manager promptly if analyzers are found out of tolerance, preferably before leaving the site.
- 6.6 Audit data, including all completed data sheets and checklists, should be delivered to the ENSR QA department at ENSR, Westford, MA.

TABLE 1
CORRECTION FACTORS FOR NWS PRESSURES

Site Elevation Above Mean Sea Level		Correction Factor
Ft.	Meters	
11000	3353	0.661
10500	3200	0.674
10000	3048	0.688
9500	2896	0.701
9000	2743	0.715
8500	2591	0.779
8000	2438	0.743
7500	2286	0.757
7000	2134	0.771
6500	1981	0.786
6000	1829	0.801
5500	1676	0.817
5000	1524	0.832
4500	1372	0.848
4000	1219	0.864
3500	1067	0.880
3000	914	0.896
2500	762	0.913
2000	610	0.930
1500	475	0.947
1000	305	0.964
500	152	0.982
0	0	1.000

ENSR Corp.

Gas Dilution Calibration

Network: _____ Site: _____ Instrument: _____ S/N: _____ Date: _____
Calibrator: _____ S/N: _____ Cal Date: _____ Cylinder S/N: _____ Conc (ppm) _____ Date: _____

Initial: Zero Pot _____ Span Pot _____
Final: Zero Pot _____ Span Pot _____

Precision and Level One Check
Multipoint Calibration
Other

DAS: _____

Ship Chart: _____

Time Off: _____ **On:** _____

[illegible]

Standards Comparison

[illegible]

Signature: _____

QC Review: _____

Accepted ☐ Rejected ☐

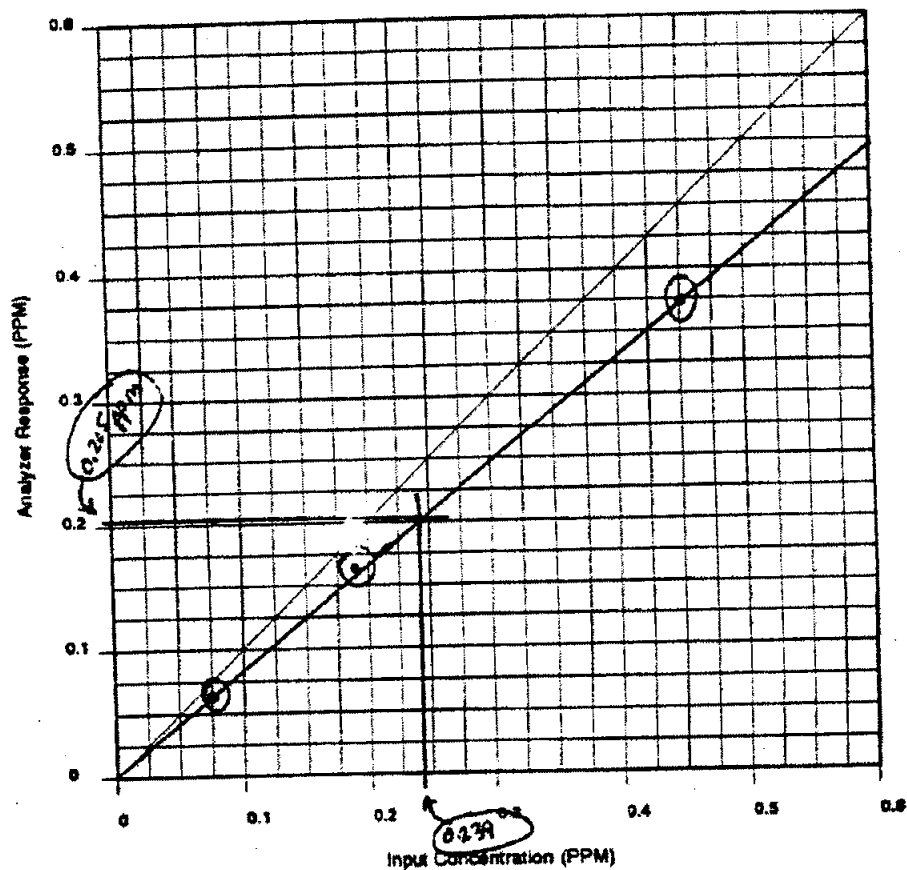
[illegible]

Figure 3. Ozone Audit Form

ENSR

Calibration Curve

Network: ENSR Date: 9/10/93
Site: ACTON Analyzer S/N: 40162
Technician: MIKE DOBROWOLSKI Calibrator S/N: 1207



Signature: Mike Dobrowolski
Reviewer: Donald White

Figure 4. Calibration Curve

VFC Sampler Audit Data Sheet (Part 1)					
Station Location	Indianapolis	Date	11/24/97	Time	2:15 PM
Sampler Model	Wedding	S/N	1040870285C		
P _s 73 mm Hg	T _a 11 °C or 284 K	Unusual Conditions None			
9					
Audit Orifice S/N	10387	Orifice Calibration Date 7/22/97			
Orifice Calibration Relationship:	m = 1.2430	b = -0.0062	r = 0.9999		
Sampler Calibration Relationship:	m = Lookup	b = Table	r = Used		
Orifice Pressure Drop (ΔH ₂ O)	4.5	in. H ₂ O	Q _a (orifice)*	1.063	m ³ /min
	With Orifice Installed		Without Orifice Installed		
Stagnation Pressure (ΔP _{stg})	39.37	mm Hg	33.02	mm Hg	
Absolute Stagnation Pressure (P ₁) ^b	699.63	mm Hg	705.98	mm Hg	
Stagnation Pressure Ratio (P ₁ /P _s)	0.9467	(see note)	0.960	(see note)	
Q _s (sampler) ^c	1.121	m ³ /min	1.146	m ³ /min	
Audit Flow Rate Percentage Difference ^d	5.5	% (see note)			
Q _s (corrected sampler) ^e	1.083	m ³ /min			
Design Flow Rate Percentage Difference ^f	-4.2	%			
<p>Note: If P₁/P_s is less than the values that are listed in the manufacturer's lookup table or if audit flow rate percentage difference is greater than ±10 percent, proceed to Part 2 of the VFC Sampler Audit Data Sheet. Otherwise, complete this part.</p>					
<p>* Q_a(orifice) = [(ΔH₂O) (T_a/P_s)^{1/2} - b] {1/m}</p> <p>^b P₁ = P_s - ΔP_{stg}</p> <p>^c Determine Q_s(sampler) from manufacturer's lookup table (or from alternate calibration relationship).</p> <p>^d Audit % difference = [100] $\left[\frac{Q_s(\text{sampler}) - Q_s(\text{audit})}{Q_s(\text{audit})} \right]$ where Q_s(sampler) is measured with the orifice installed.</p> <p>^e Q_s(corrected sampler) = Q_s(sampler) $\left[\frac{100 - \text{Audit \% difference}}{100} \right]$ where Q_s(sampler) is measured without the orifice installed.</p> <p>^f Design flow rate % difference = [100] $\left[\frac{Q_s(\text{corrected sampler}) - 1.13}{1.13} \right]$</p>					
Auditor	R. Wright	Observer	K. McDaniel		

Figure 5. VFC Sampler Audit Data Sheet

VFC Sampler Audit Data Sheet (Part 2)								
Station Location		Indianapolis		Date	11/24/97	Time	2:15 PM	
Sampler Model		Wedding		S/N	1040870285C			
P_a	73 mm Hg	T_a	11 °C	284 K	Unusual Conditions			None
Audit Orifice S/N		10387		Orifice Calibration Date		7/22/97		
Orifice Calibration Relationship:				$m =$	1.2430	$b =$	-0.0062	
				$r =$	0.9999			

Plate No.	AH ₂ O (in.)	$\bar{A}P_{stag}$ (mm Hg)	P_1 (mm Hg)	P_1/P_a (mm Hg)	$(P_1/P_a)^{1/2}$	Q_a (Orifice) (m ³ /min)
1	4.5	39.37	699.63	0.9467	0.9730	1.063
2	4.35	44.45	694.55	0.9399	0.9695	1.045
3	4.1	52.07	686.93	0.9295	0.9641	1.015

Provisional Sampler Calibration Relationship: $(X = Q_a \text{ (Orifice)}, Y = (P_1/P_a)^{1/2})$

$m =$ 0.1849 $b =$ 0.7764 $r =$ 0.9998

Measurements with filter installed and Audit Orifice Transfer Standard removed:

$\bar{A}P_{stag}$	33.02	mm Hg	P_1^*	705.98	mm Hg
P_1/P_a	0.9553		$(P_1/P_a)^{1/2}$	0.9774	
Q_a (audit) ^b	1.087	m ³ /min	Q_a (sampler) ^c	1.146	m ³ /min
Audit Flow Rate Percentage Difference ^d				5.4	%
Design Flow Rate Percentage Difference ^e				-3.8	%

^a $P_1 = P_a - \bar{A}P_{stag}$

^b Q_a (audit) is determined from the provisional sampler calibration relationship.

^c Q_a (sampler) is determined from the lookup table or alternative calibration relationship.

^d Audit flow rate % difference = $[100] \left[\frac{Q_a \text{ (sampler)} - Q_a \text{ (audit)}}{Q_a \text{ (audit)}} \right]$

^e Design flow rate % difference = $[100] \left[\frac{Q_a \text{ (audit)} - 1.13}{1.13} \right]$

Auditor **R. Wright** Observer **K. McDaniel**

Figure 5. VFC Sampler Audit Sheet (Continued)

Technical Instruction

Documentation of Field Calibration of Continuous Air Quality Analyzers

Author: Patrick McKean
TechIn No.: 2901-001
Revision: 1
Date: 3rd Quarter, 2006

1.0 Purpose and applicability

- 1.1 This Technical Instruction applies to all ENSR calibrations of continuous air quality analyzers and conforms to the requirements of ENSR SOP 2600 - Field Calibration of Continuous Air Quality Analyzers.
- 1.2 Standard ENSR Forms are included with SOP's for each type gas analyzer used by ENSR. Refer to ENSR SOP 2630-101, SOP 2600-224, and SOP 2600-136 for calibration forms for O₃, SO₂, and NO_x analyzers respectively for all field calibrations of continuous air quality analyzers
- 1.3 Specific instructions on method of calibration and on operation of a calibrator are found in Technical Instructions and/or manufacturers' manuals pertaining to that equipment.

2.0 General

- 2.1 Determine the appropriate spreadsheet form on the basis of calibration method.
- 2.2 The top section of the forms is for the identification of the analyzer being calibrated, the standards used, and the location and date.
- 2.3 Perform all routine checks required by SOPS, TECHINs, and instrument manuals before beginning the calibration. This information should be entered on weekly check sheets specific to the analyzer to be calibrated or in the Field Station Log.
- 2.4 Enter all flow settings and flows (cc/min) appropriate for the calibration method, and enter the actual concentration corresponding to those settings. If the form is filled out properly, it will be possible for anyone to calculate "Input PPM_D" from the information on the form and get the same numbers.
- 2.5 Some of the column headings on the forms have "O" or "D" in parentheses with asterisks. The numbers in these columns are used in the equation near the lower right-hand corner of the forms to calculate the corresponding $\Delta\%$. The $\Delta\%$ should be calculated for each reading during the calibration so that the technician knows whether all readings are within $\pm 10\%$ of designated (see ENSR SOP 2600).
- 2.6 It is good practice to choose the approximate concentrations you wish to generate with your calibrator first, and then calculate flows. Computations are performed in electronic spreadsheets and should be checked carefully to see if values are reasonable. Before accepting entering the numbers on your form:
 - 2.6.1 Make sure all flows are within the useable range of the flowmeters; and
 - 2.6.2 Make sure the concentrations are well spaced over the range with the highest concentration at 80-90% of full scale.
- 2.7 The forms are not the only source of documentation. If strip charts are used at the site, the strip chart record of the calibration should be clearly labeled with an explanation of each deflection of the pen, the exact time the instrument was taken off ambient sampling, the exact time it was returned to

Technical Instruction

Documentation of Field Calibration of Continuous Air Quality Analyzers

Author: Patrick McKean
TechIn No.: 2901-001
Revision: 1
Date: 3rd Quarter, 2006

ambient, the date, and name of the technician. The Field Station Log should contain an account of everything anybody does inside the shelter, including, of course, calibrations.

- 2.8** Analyzer responses are recorded in volts (taken from a DMM) and in ppm (taken from the DAS or strip chart if an historic data base is used - as in most PSD networks). $\Delta\%$ is calculated from ppm values. If a discrepancy greater than ± 0.2 volts exists between DMM and recorder, the recorder must be recalibrated.

3.0 Gas Dilution Systems (gases other than NO)

- 3.1** Use the appropriate spreadsheet for the specific gas dilution systems.
- 3.2** Enter the gas cylinder number (this number consists of 2 letters and 4 numerals) and concentration in the appropriate spaces. These values can be found on the tag attached to the cylinder, or in the laboratory certification documents.
- 3.3** The flow meters or flow controllers in the dilution system will each have a calibration curve relating flow setting (usually VDC) to flow (cc/min or 1pm). The numbers entered under Flow Setting and Flow should represent points on those curves. The values entered in the columns entitled "Dil. or Total (for Perm.)" should represent the dilution flow, not the total flow.
- 3.4** The numbers in the two "Flow" columns and in the "Input PPM_D" column are related to the cylinder concentration by the following equation:

$$\text{Input PPM}_D = \frac{\text{Cylinder Conc.} \times \text{Gas Flow}}{(\text{Gas Flow} + \text{Dil. Flow})}$$

- 3.5** Analyzer readings are entered in volts and ppm, but $\Delta\%$ is calculated from ppm values.

4.0 Nitric Oxide Dilution and Gas Phase Titration (GPT)

- 4.1** For calibrations of NO/NO_x analyzers, refer to the calibration forms on the laptop.
- 4.2** All appropriate spaces should be filled in on both forms.
- 4.3** Flow setting and flow columns are filled out as in 3.3 and 3.4. The NO dilution portion of the calibration is essentially the same as other gas dilution calibrations.
- 4.4** For the gas phase titration portion of the calibration:
- 4.4.1** The flows and flow settings on this form are the ones that correspond to the highest NO concentration; these flows do not change during GPT.
- 4.4.2** The "O₃ Setting" column is for any flow setting or switch position that directly affects the amount of ozone being produced. In some cases there may be two or more different settings that are used to manipulate the rate of ozone production.

Technical Instruction

Documentation of Field Calibration of Continuous Air Quality Analyzers

Author: Patrick McKean
TechIn No.: 2901-001
Revision: 1
Date: 3rd Quarter, 2006

- 4.4.3 The "Input NO_x" column is for the total amount of NO + NO₂. This value does not change during GPT.
- 4.4.4 The column labeled "NO₂/O₃ Input - NO₂GPT" is for ΔNO, which for a calibrated analyzer will be equal to the actual NO₂ input. The ΔNO is determined by subtracting the ppm response of the NO channel at each ozone setting from the NO channel response before the ozone is turned on.
- 4.4.5 The columns labeled "NO₂/O₃ Analyzer Response" will be the NO₂ channel response, in this case. Enter NO₂ responses observed during GPT in the far right-hand "Adjusted" column.
- 4.4.6 Converter Efficiency.

A data form has been developed for determining the converter efficiency. The following procedure is for use with this data form.

1. Values for Columns 1, 2, and 3 of the converter efficiency data form are taken directly from the calibration data form.

Converter Efficiency Data Form (Example)

Calibration point	1 [NO ₂] _{OUT} (x)	2 [NO _x] _{ORIG}	3 [NO _x] _{REM}	4 [NO ₂] _{CONV} (y)
Zero set point	0.000	0.450	0.450	0.000
80% URL	0.400	0.450	0.440	0.390
1	0.200	0.450	0.445	0.195
2	0.100	0.450	0.450	0.100

Slope (b) = 0.97
Converter efficiency = 100 x b = 97%
[NO₂]_{CONV} = [NO₂]_{OUT} - ([NO_x]_{ORIG} - [NO_x]_{REM})

2. Calculate the quantity of NO₂ converted to NO, labeled [NO₂]_{CONV}, for each point using the following equation:

$$[NO]_{CONV} = [NO_2]_{OUT} - ([NO_x]_{ORIG} - [NO_x]_{REM})$$

3. Plot [NO₂]_{CONV} (y-axis) versus [NO₂]_{OUT} (x-axis), and the converter efficiency curve, and then calculate the slope (b) of the curve using either the spreadsheet or an appropriate calculator using the method of least squares regression.
4. Multiply the slope (b) of the curve by 100 to determine average converter efficiency; if the efficiency is less than 96%, either replace or service the converter.

Technical Instruction

Documentation of Field Calibration of Continuous Air Quality Analyzers

Author: Patrick McKean
TechIn No.: 2901-001
Revision: 1
Date: 3rd Quarter, 2006

5.0 In-Station Calibrator Verification

5.1 This should be done immediately after any calibration.

5.2 In the box at the lower left-hand corner of the form, one column is labeled "Concentration." Choose two of the concentrations generated for the calibration of the analyzer and enter them in this column (one low and one high concentration). Enter the calibrator settings corresponding to those concentrations under "Reference Calibrator Flow Setting" (it may be necessary to alter this column to provide for two flow settings for each concentration). Enter two adjusted analyzer readings (from the calibration just completed) under "Reference Calibrator Analyzer Response." From the documentation of the In-Station Calibrator, determine the flow settings required to produce the same concentrations and enter them under "In-Station Calibrator Flow Setting." Set the in-station calibrator to each of these settings, directing the gas into the analyzer, and enter the analyzer responses in volts and ppm under "In-Station Calibrator Analyzer Response" (as always, when taking analyzer readings, wait until you are sure the output has stopped changing). The $\Delta\%$ is calculated, for each test concentration, as follows:

$$\Delta\% = \frac{100 \times (\text{ppm response to In-Station}) - (\text{ppm response to ref.})}{(\text{ppm response to reference})}$$

5.3 If this comparison shows the in-station calibrator to be off by more than 10% on either test point, it must be recalibrated. See ENSR SOP 2600.

6.0 Calibration Curve

- 6.1 When a calibration check shows an instrument out of tolerance, plotting a graph of the results may be the best way to begin diagnosing the problem.
- 6.2 Use the spreadsheet functions to graph calibration results.

Technical Instruction

Documentation of Field Calibration of Continuous Air Quality Analyzers

Author: Patrick McKean
TechIn No.: 2901-001
Revision: 1
Date: 3rd Quarter, 2006

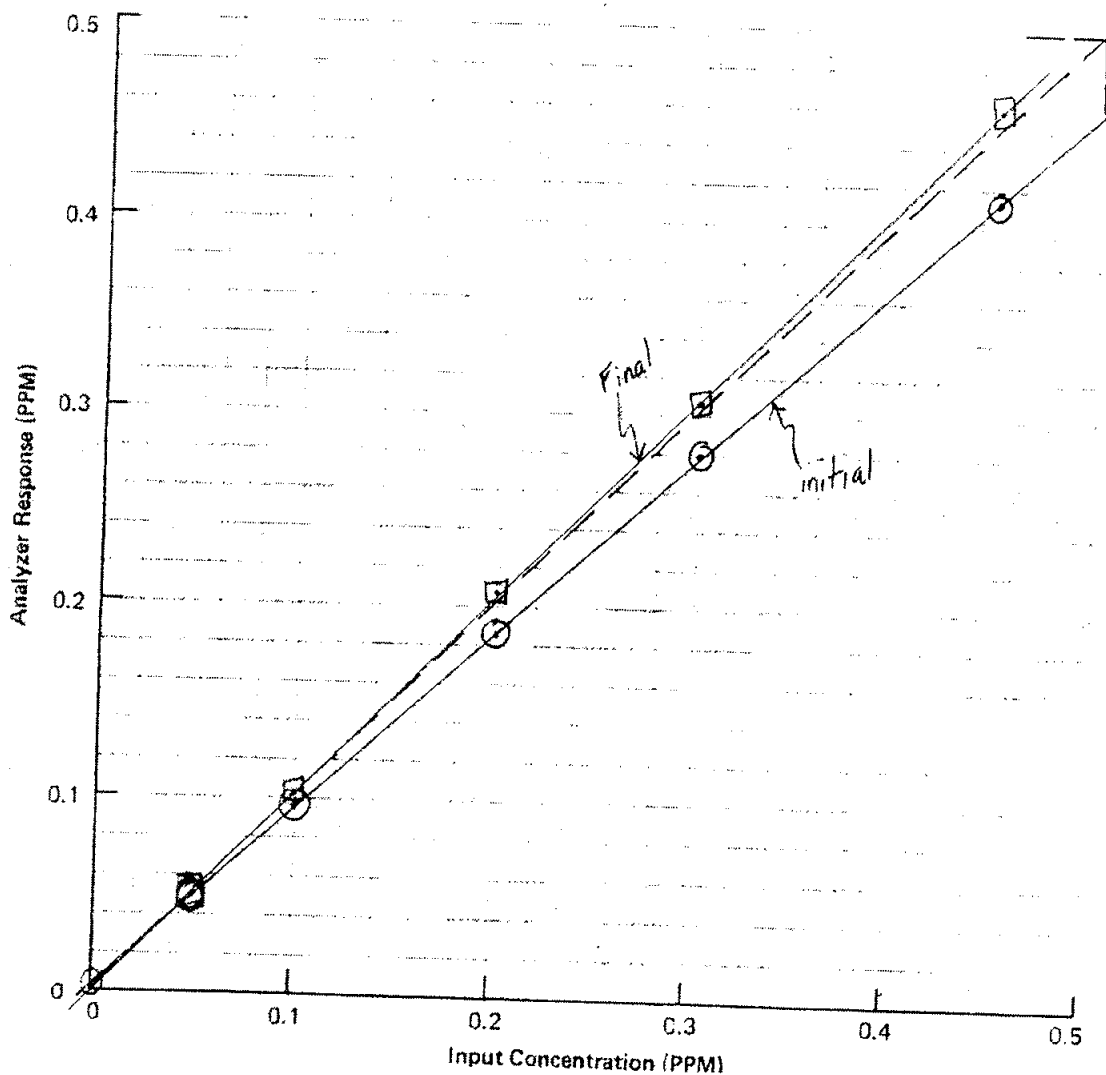
Figure 10.1

ENSR

CALIBRATION CURVE

Network: NBC
Site: Prime time
Site No.: 34
Operator: Wilkes J. Barre

Date: 8/20/85
Time: 1530
Analyzer S/N: 9999
Calibrator S/N: 1111



SOP NUMBER: 2901-100

Quality Control Documentation
Review Procedure

Date: 4th Qtr., 1994

Revision Number: 1

Author: Scott Whittemore

Discipline: Air Toxics Monitoring

1.0 PURPOSE AND APPLICABILITY

This procedure is intended to serve as a guideline for the Quality Control (QC) review of air quality and meteorological instrumentation field calibration documentation. A working knowledge of and access to, applicable SOPs is necessary for the proper execution of this QC activity.

2.0 RESPONSIBILITIES

- 2.1 Project Managers or their designees are responsible for the review of all field calibration documentation generated in support of the proper operation of the monitoring program. The reviewer must sign the data sheets, indicate approval or rejection of the calibration and provide a brief explanation, as needed for, calibration rejections.
- 2.2 This process must be conducted on a timely basis; maximum interval of one week between receipt and review of data is suggested.
- 2.3 Project managers are responsible for the training of project personnel should QC review of calibration documentation indicate the need for additional training.
- 2.4 Quality Assurance (QA) personnel, by audit and periodic spot reviews, are responsible for assuring that all supporting project documentation have been properly QC reviewed.

3.0 REQUIRED MATERIALS

- ENSR SOP 2400 - Traceability of Standards
- ENSR SOP 2600 - Field Calibration Control Plan
- ENSR SOP 2620-001 - High Volume Sampler Calibration
- ENSR SOP 2630 - Routine Data Collection and Evaluation
- Individual SOPs specific to the calibration being reviewed.

4.0 METHOD

4.1 All documentation must be properly identified. This includes:

- Network and station name;
- Make, model, and serial number of instrument calibrated;
- Calibration date; and
- Technician identification.

4.2 All test equipment, calibrators, and calibration standards must be properly identified as to make, model, and serial number. Calibration date or concentration verification date of gas cylinders must be included. Refer to ENSR SOP 2400, Traceability of Standards for calibration periods.

Note: Test equipment is allowed a two-week grace period for use beyond the calibration due date. Data generated from test equipment beyond this grace period is considered suspect until the subsequent calibration indicates proper operation of the test equipment within accepted tolerances.

4.3 All calibrator or test equipment settings used in generating each test point must be documented. Use the calibration equations and spot check several calculations. Ensure that the calibrator was used within the calibration range.

4.4 Verify that data acquisition system and, if applicable, strip chart recorder responses are recorded on the calibration data sheet.

4.5 Review the recorded units. Verify whether particulate samplers were calibrated in standard or actual units. Determine whether wind speed sensors were calibrated in meters per second or miles per hour, etc.

4.6 If the analyzer or sensor was adjusted, the percent difference ($\Delta\%$) of final calibration values must be within the tolerance limits specified by the applicable instrument-specific SOP, or those of the QA Program Plan, if different. Exceptions to this rule are:

- in the case of a final calibration of an instrument just prior to removal from a site, or
- when the analyzer or sensor fails during the calibration and must be replaced.

5.0 QUALITY CONTROL

- 5.1** Recalibration must be performed as soon as possible whenever a field calibration is rejected.
- 5.2** Audits and periodic reviews of archived project files will be performed to verify adherence to this procedure.
- 5.3** Instruction and/or training must be provided to all field personnel who appear to have a conceptual misunderstanding of the calibration process based on submitted data.

6.0 DOCUMENTATION

- 6.1** Following review of the calibration data sheet, initial, date and indicate whether the calibration is accepted or rejected on the bottom right hand corner of each sheet.

7.0 REFERENCES

Not applicable.

TECH NUMBER: 2990-001
**Technical Instruction:
 Calculation of Precision and
 Accuracy Statistics**
Date: 3rd Qtr. 2006

Revision Number: 3

Author: V. Scheetz

Discipline: Air Measurements

1.0 APPLICABILITY/RESPONSIBILITY

This document describes the standard ENSR procedures for the quarterly calculation of precision and accuracy statistics for continuous and daily (TSP) air measurement data.

The procedures described herein are applicable to most air measurements programs. Some programs require the precision and accuracy statistics while others just require the precision statistics. The requirements should be verified with the appropriate program manager.

It is the responsibility of the Field Technician to perform the bi-weekly precision checks, the Quality Assurance Department to perform audits and of the data processing group (this may vary depending on the project) to generate the precision and accuracy statistics.

2.0 GENERAL INFORMATION

2.1 See TECHIN 2600-001 for details on performing field precision checks and TECHIN 2900-001 for details on performing field audits.

2.2 In order to comply with the quality assurance requirements of 40 CFR, Part 58, Appendix B, and certain state regulatory agencies the precision and accuracy of continuous and daily air quality measurements are reported quarterly.

Precision checks are performed once every two weeks for each continuous air quality measurement parameter for the purpose of quantifying the degree of variability in the data. A precision check is performed by generating an NBS-traceable test atmosphere containing approximately 0.080 to 0.100 ppm (8 – 10 ppm for CO) of the pollutant being monitored. The test atmosphere is delivered to the analyzer through as much of the ambient air sample delivery system as possible. The accuracy of the analyzer's response to the precision test atmosphere is quantified in percent as follows:

$$\Delta\text{Percent} = \left[\frac{\text{Analyzer Response} - \text{Known Input}}{\text{Known Input}} \right] \times 100$$

Network accuracy for each quarter is computed for each pollutant by compiling the accuracy statistics of all equivalent analyzers of the pollutant. This yields a series of 95% confidence

intervals. Each interval represents the accuracy of the network data for the pollutant within the represented portion of the measurement range.

3.0 METHODS

- 3.1** Bi-weekly precision checks at the proper concentration should be listed on the Precision & Level 1 Forms (see attachments 1 & 2). There should be a minimum of six precision checks per quarter for each analyzer - two from each month in the quarter. Precision checks done during periods of invalid data should not be used in the calculations.

If an analyzer is adjusted during the process of conducting a precision check, only the results of the precision check conducted before adjustment should be used in the calculations. This includes zero adjustments. If there is evidence that precision checks are being conducted after zero or span adjustments and the pre-adjustment precision checks are not being performed, notify QA and the program manager.

Quarterly audit results should be found in the audit reports generated by the QA department.

- 3.2** Calculations should be performed using PC-based spreadsheet programs or equivalent time-saving methods.

- 3.3** Precision - (continuous air measurements)

- 3.3.1** Single Instrument Precision - (continuous air measurements)

Calculate the percentage difference (d_i) for each precision check as follows:

$$d_i = \frac{Y_i - X_i}{X_i} \times 100$$

Where:

Y_i = analyzer's indicated concentration from the i-th precision check.

X_i = known concentration of the test gas used for the i-th precision check.

The average (\bar{d}_j) and standard deviation (S_j) are calculated from the following equations:

$$\bar{d}_j = \frac{1}{n} \sum_{i=1}^n d_i$$

$$S_j = \sqrt{\frac{1}{n-1} \left[\sum_{i=1}^n d_i^2 - \frac{1}{n} \left(\sum_{i=1}^n d_i \right)^2 \right]}$$

Where:

n is the number of precision checks on the instrument made during the period.

\bar{d}_j = the average percent difference for the quarter.

The 95 percent probability limits for single analyzer precision are calculated as follows:

Upper 95 percent Probability Limit = $\bar{d}_j + 1.96 S_j$

Lower 95 percent Probability Limit = $\bar{d}_j - 1.96 S_j$

3.4 Accuracy - (continuous air measurements)

3.4.1 Single Analyzer Accuracy - (continuous air measurements)

Calculate the percentage difference (d_i) for each audit concentration using the following equation:

$$d_i = \frac{Y_i - X_i}{X_i} \times 100$$

3.5 Precision - (manual methods – TSP and PM₁₀)

Estimates of the precision are calculated from the results obtained from colocation of two samplers. At the end of each calendar quarter, calculate a combined precision probability interval for all colocated samplers for each pollutant.

3.5.1 Single Instrument Precision - (manual methods - TSP and PM₁₀)

For each of the paired measurements, calculate the percentage difference (d_i) using the equation below.

$$d_i = \frac{Y_i - X_i}{(X_i + Y_i)/2} \times 100$$

where:

Y_i = the concentration of pollutant measured by the duplicate sampler

X_i = concentration of pollutant measured by the sampler reporting air quality for the site

For each site, calculate the quarterly average percentage difference (d_j), and the standard deviation (S_j), using the equations below.

$$\overline{d_j} = \frac{1}{n} \sum_{i=1}^n d_i$$

$$S_j = \sqrt{\frac{1}{n-1} \left[\sum_{i=1}^n d_i^2 - \frac{1}{n} \left(\sum_{i=1}^n d_i \right)^2 \right]}$$

where:

n = number of precision checks (collocated days) during the quarter.

3.6 Accuracy - (manual methods - TSP and PM_{10})

Estimates of the accuracy of TSP data are calculated from the results of quarterly audits in which the High Volume Sampler (HI-VOL) flow rate measurement is audited with an orifice of NBS-traceable calibration. Readings of pressure drop across the orifice, taken with a water manometer, are converted to flow rates (in CFM) for comparison with concurrent flow readings from the site measurement device and calibration curve.

3.6.1 Single Sampler Accuracy (TSP and PM_{10})

For the flow rate audit, let

X_i = known flow rate

Y_i = indicated flow rate

Calculate the percentage difference (d_i) for each audit using the following equation.

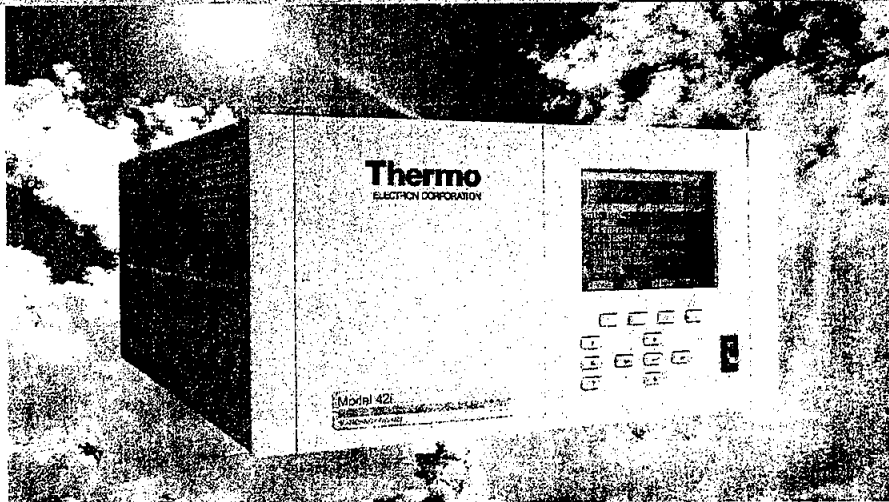
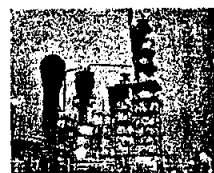
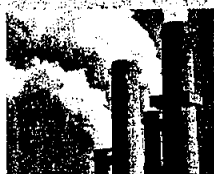
$$d_i = \frac{Y_i - X_i}{X_i} \times 100$$

Appendix D

Manufacturer's Specifications

Model 42i NO-NO₂-NO_x Analyzer

Chemiluminescent gas analyzer with enhanced communication capabilities for ambient air and source emissions monitoring



Key Features

- Ethernet connectivity for efficient remote access
- Enhanced user interface with one button programming and large display screen
- Flash memory for increased data storage and user downloadable software
- Enhanced electronics design optimizes product commonality
- Improved layout for easier accessibility to components

A change is in the air

The industry's new best-of-breed. Our customers told us exactly what they're looking for in a gas monitoring solution: reliability, simplicity, ease of use. The new iSeries platform delivers on all counts - and then goes a step farther. The flagship product in Thermo's new iSeries product line is the Model 42i NO-NO₂-NO_x analyzer.

Using chemiluminescence technology, the Model 42i measures the amount of nitrogen oxides in the air from sub-ppb levels up to 100ppm. The Model 42i is a single Chamber, single photomultiplier tube design that cycles between the NO and NO_x modes.

The 42i has independent outputs for NO, NO₂, and NO_x and each can be calibrated separately. Dual range and Auto range are standard features as well. If required, the instrument can be operated

continuously in either the NO or NO_x modes allowing for response times of less than 5 seconds.

Temperature and pressure correction are standard features. User settable alarm levels for concentration and for a wide variety of internal diagnostics are available from an easy to follow menu structure.

This state-of-the-art gas analyzer offers features such as an ethernet port as well as flash memory for increased data storage.

Ethernet connectivity provides efficient remote access, allowing the user to download measurement information directly from the instrument without having to be on-site.

You can easily program soft-keys to allow you to jump directly to frequently accessed functions, menus or screens. The larger interface screen can display up to five lines of measurement information.

Comprehensive Service Solutions

To maintain optimal product performance, you need immediate access to experts worldwide, as well as priority status when your air quality equipment needs repair or replacement. Thermo Electron offers comprehensive, flexible support solutions for all phases of the product lifecycle. Through predictable, fixed-cost pricing, Thermo services help protect the return on investment and total cost of ownership of your Thermo Electron air quality products.

Product Specifications

Preset Ranges	0-0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50 and 100 ppm 0-0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100 and 150 mg/m ³
Custom Ranges	0-0.05 to 100 ppm 0-0.1 to 150 mg/m ³
Zero Noise	0.20 ppb RMS (60 second averaging time)
Lower Detectable Limit	0.40 ppb (60 second averaging time)
Zero Drift (24 hour)	< 0.40 ppb
Span Drift (24 hour)	+/-1% full scale
Response Time	40 seconds (10 second average time) 80 seconds (60 second average time) 300 seconds (300 second average time)
Precision	+/-0.4 ppb (500 ppb range)
Linearity	+/-1% full scale
Sample Flow Rate	0.6 liters/min.
Operating Temperature	15°C - 35°C
Power Requirements	100 vac, 115 vac, 220-240 vac +/-10% @ 300W
Size and Weight	16.75"(W) x 8.62"(H) x 23"(D), 55 lbs. (25 kg)
Outputs	Selectable Voltage, RS232/RS485, TCP/IP, 10 Status Relays, and Power Fail Indication (standard). 0-20 or 4-20 mA Isolated Current Outout (optional)
Inputs	16 Digital Inputs (standard), 8 0-10Vdc Analog Inputs (optional)

Ordering Information

Model 42i NO-NO₂-NO_x Analyzer

Choose from the following configurations/options to customize your own Model 42i

Voltage options:

A = 120 Vac 50/60 Hz (standard)
B = 220 Vac 50/60 Hz
J = 100 Vac 50/60 Hz

Internal zero / span:

N = No zero / span assembly (standard)
Z = Internal zero span assembly
P = Internal permeation span source with zero/span assembly

Converter options:

M = Molybdenum (standard)
S = Stainless steel

Sample handling:

S = Standard plumbing (standard)
A = Ammonia scrubber

Ozone handling:

D = Drierite scrubber (standard)
P = Permeation dryer

Optional I/O:

A = None (standard)
C = I/O expansion board
(4-20mA outputs - 6 channels, 0-10V inputs - 8 channels)

Mounting Hardware:

A = Bench mounting (standard)
B = Ears & handles, EIA
C = Ears & handles, Retrofit

Your Order Code: 42i - _____

Other options:

- Teflon particulate filter
- Ozone particulate filter
- Rack mounts
- Rear extender



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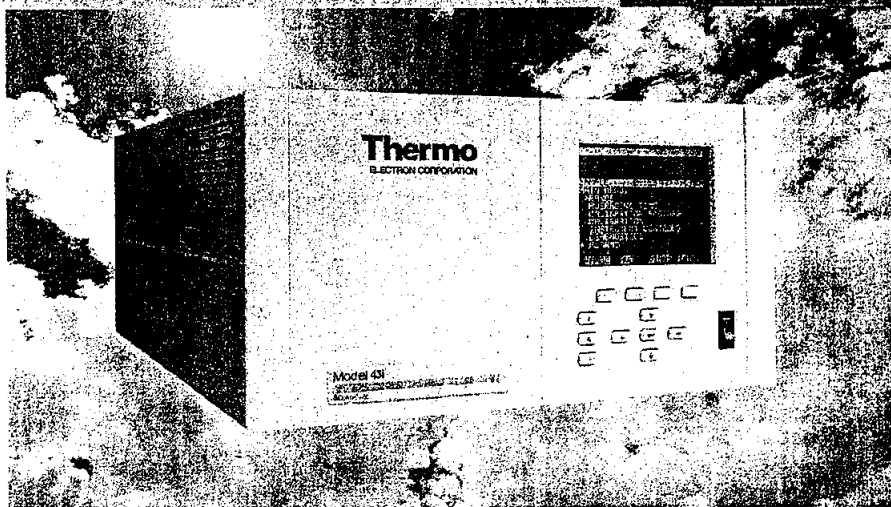
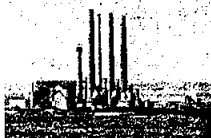
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(508) 520-0430
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Model 43i SO₂ Analyzer

Pulsed fluorescence gas analyzer with enhanced communication capabilities for ambient air and source emissions monitoring



Key Features

- Ethernet connectivity for efficient remote access
- Enhanced user interface with one button programming and large display screen
- Flash memory for increased data storage and user downloadable software
- Enhanced electronics design optimizes product commonality
- Improved layout for easier accessibility to components

A change is in the air

The industry's new best-of-breed. Our customers told us exactly what they're looking for in a gas monitoring solution: reliability, simplicity, ease of use. The new iSeries platform delivers on all counts - and then goes a step farther. A core product in Thermo's new iSeries product line is the Model 43i SO₂ analyzer.

Using pulsed fluorescence technology, the Model 43i measures the amount of sulfur dioxide in the air up to 10ppm. The pulsing of the U.V. source lamp serves to increase the optical intensity whereby a greater U.V. energy throughput and lower detectable SO₂ concentration are realized. Reflective bandpass filters, as compared to commonly used transmission filters, are less subject to photochemical degradation

and more selective in wavelength isolation. This results in both increased detection specificity and long term stability.

This state-of-the-art gas analyzer offers features such as an ethernet port as well as flash memory for increased data storage.

Ethernet connectivity provides efficient remote access, allowing the user to download measurement information directly from the instrument without having to be on-site.

You can easily program soft-keys to allow you to jump directly to frequently accessed functions, menus or screens. The larger interface screen can display up to five lines of measurement information while primary screen remains visible.

Product Specifications

Preset Ranges	0-0.05, 0.1, 0.2, 0.5, 1, 2, 5, and 10 ppm 0-0.2, 0.5, 1, 2, 5, 10, 20, and 25 mg/m ³
Extended Ranges	0-0.05, 1, 2, 5, 10, 20, 50 and 100 ppm 0-2, 5, 10, 20, 50, 100, 200, and 250 mg/m ³
Custom Ranges	0-0.05 to 10 ppm 0-0.2 to 250 mg/m ³
Zero Noise	1.0 ppb RMS (10 second averaging time), 0.5 ppb RMS (60 second averaging time), 0.25 ppb RMS (300 second averaging time)
Lower Detectable Limit	2.0 ppb (10 second averaging time), 1.0 ppb (60 second averaging time), 0.5 ppb (300 second averaging time)
Zero Drift (24 hour)	Less than 1 ppb
Span Drift (24 hour)	+/-1%
Response Time	80 seconds (10 second average time) 110 seconds (60 second average time) 320 seconds (300 second average time)
Precision	1% of reading or 1 ppb (whichever is greater)
Linearity	+/-1% full scale ≤ 100ppm
Sample Flow Rate	0.5 liters/min. (standard) 1 liter/min. (optional)
Interferences (EPA levels)	< lower detectable limit except for the following: NO < 3 ppb, M-Xylene < 2 ppb, H ₂ O < 2% of reading
Operating Temperature	20°C - 30°C
Power Requirements	100 vac, 115 vac, 220-240 vac +/-10% @ 165W
Size and Weight	16.75"(W) x 8.62"(H) x 23"(D), 48 lbs. (21.8 kg)
Outputs	Selectable Voltage, RS232/RS485, TCP/IP, 10 Status Relays, and Power Fail Indication (standard). 0-20 or 4-20 mA Isolated Current Output (optional)
Inputs	16 Digital Inputs (standard), 8 0-10Vdc Analog Inputs (optional)

Ordering Information

Model 43i SO₂ Analyzer

Choose from the following configurations/options to customize your own Model 43i

Voltage options:

A = 120 Vac 50/60 Hz
B = 220 Vac 50/60 Hz
J = 100 Vac 50/60 Hz

Internal zero /span:

N = No zero / span assembly
Z = Internal zero / span assembly
P = Internal permeation span source with zero/span assembly

Kicker type:

S = Standard
H = Heated

Optional I/O:

A = No optional I/O (standard)
C = 0-20, 4-20mA current output - 6 channels, 0-10V analog input - 8 channels

Mounting hardware:

A = Bench mounting (standard)
B = Ears & handles, EIA
C = Ears & handles, retrofit

Your Order Code: 43i - _ _ _ _ _

Other options:

- Teflon particulate filter
- Rack mounts
- Rear extender

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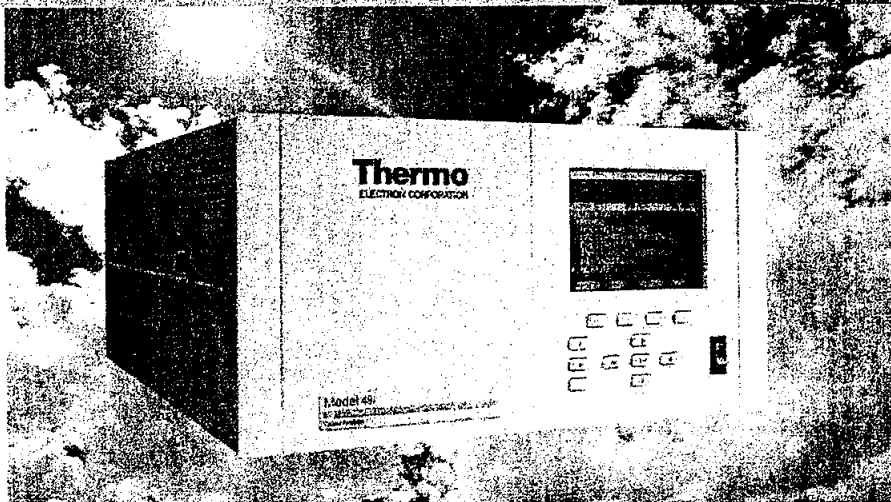
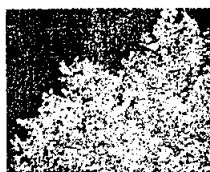
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The Netherlands

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Model 49i Ozone Analyzer

UV Photometric gas analyzer with enhanced communication capabilities for ambient air monitoring.



A change is in the air

The industry's new best-of-breed. Our customers told us exactly what they're looking for in a gas monitoring solution: reliability, simplicity, ease of use. The new iSeries platform delivers on all counts - and then goes a step farther.

One of the criteria pollutant analyzers in Thermo's new iSeries product line is the Model 49i O_3 analyzer.

Using UV Photometric technology, the Model 49i measures the amount of ozone in the air from ppb levels up to 200ppm. The Model 49i is a dual cell photometer, the concept adopted by the NIST for the national ozone standard.

Dual range and auto range are standard features in this instrument. Because the instrument has both sample and reference flowing at the same time a response time of 20 seconds can be achieved.

Temperature and pressure correction are standard features. User settable alarm levels for concentration and for a wide variety of internal diagnostics are available from an easy to follow menu structure.

This state-of-the-art gas analyzer offers features such as an ethernet port as well as flash memory for increased data storage and field upgradability.

Ethernet connectivity provides efficient remote access, allowing the user to download measurement information directly from the instrument without having to be on-site.

You can easily program soft-keys to allow you to jump directly to frequently accessed functions, menus or screens. The larger interface screen can display measurement information and status, while viewing menu and operational screens.

Key Features

- Ethernet connectivity for efficient remote access
- Enhanced user interface with one button programming and large display screen
- Flash memory for increased data storage and user downloadable software
- Enhanced electronics design optimizes product commonality
- Improved layout for easier accessibility to components

Comprehensive Service Solutions

To maintain optimal product performance, you need immediate access to experts worldwide, as well as priority status when your air quality equipment needs repair or replacement. Thermo Electron offers comprehensive, flexible support solutions for all phases of the product lifecycle. Through predictable, fixed-cost pricing, Thermo services help protect the return on investment and total cost of ownership of your Thermo Electron air quality products.

Product Specifications

Preset Ranges	0-0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100 and 200 ppm 0-0.1, 0.2, 1, 2, 5, 10, 20, 50, 100, 200 and 400 mg/m ³
Custom Ranges	0-0.05 to 200 ppm 0-0.1 to 400 mg/m ³
Zero Noise	0.25 ppb RMS (60 second averaging time)
Lower Detectable Limit	0.50 ppb
Zero Drift (24 hour)	< 1.0 ppb
Span Drift	<1% full scale per month
Response Time	20 seconds (10 second lag time)
Precision	1.0 ppb
Linearity	+/-1% full scale
Sample Flow Rate	1-3 liters/min.
Operating Temperature	20°C - 30°C
Power Requirements	100 vac, 115 vac, 220-240 vac +/-10% @ 150W
Size and Weight	16.75"(W) x 8.62"(H) x 23"(D), 55 lbs. 425 mm (W) x 219 mm (H) x 584 mm (D), 25 kg
Outputs	Selectable Voltage, RS232/RS485, TCP/IP, 10 Status Relays, and Power Fail Indication (standard). 0-20 or 4-20 mA Isolated Current Outout (optional)
Inputs	16 Digital Inputs (standard), 8 0-10vdc Analog Inputs (optional)

Ordering Information

Model 49i O₃ Analyzer

Choose from the following configurations/options to customize your own Model 49i

Voltage options:

A = 115 Vac 50/60 Hz (standard)
B = 220/240 Vac 50/60 Hz
J = 100 Vac 50/60 Hz

Internal zero / span:

1 = No sample/cal valve (standard)
2 = Internal sample/cal valve assembly
3 = Internal Ozonator setup (including sample/cal valve)

Zero Air Source

N = No Zero Air Source (standard)
Z = Zero Air Source (External Pump)

Optional I/O:

A = None (standard)
C = I/O expansion board
(4-20mA outputs - 6 channels, 0-10v inputs - 8 channels)

Mounting Hardware:

A = Bench mounting (standard)
B = Ears & handles, EIA
C = Ears & handles, Retrofit

Your Order Code: 49i - _____



Other options:

- Teflon particulate filter
- Rack mounts
- Rear extender
- Terminal Block Kit & Cable 37 pin
- Terminal Block Kit & Cable 25 pin
- Cable, DB37M to open end, 6' LG.
- Cable, DB37F to open end, 6' LG.
- Cable, DB25M to open end, 6' LG.
- Cable, RS232 Null Modem

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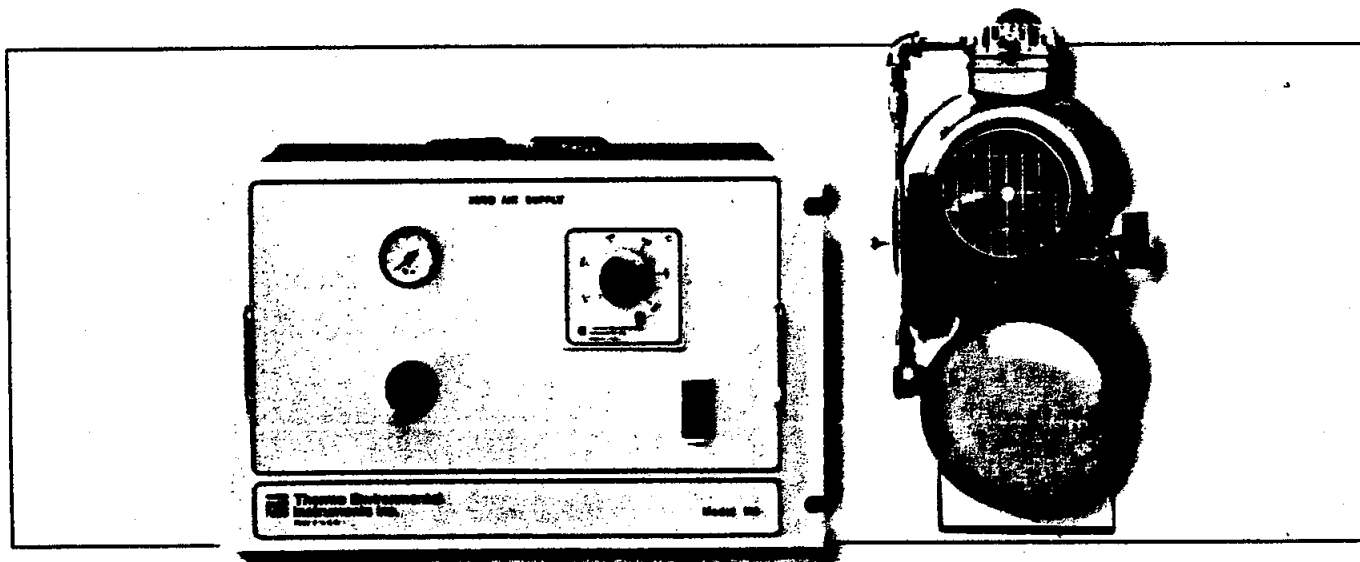
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MODEL 111

Zero Air Supply



The Thermo Environmental Model 111 Zero Air Supply is a convenient system for the generation of pollutant free "zero" gas for NO-NO_x-O₃-SO₂-CO and hydrocarbon requirements. The Model 111 uses an external compressor; the pressure regulators, chemical scrubbers, reactor and temperature controller are all contained in a single convenient case.

The Model 111 has been designed for any application where pollutant free levels of NO-NO_x-O₃-SO₂-CO and hydrocarbons are required, with flows up to *20 liters per minute at pressures of 30 psi.

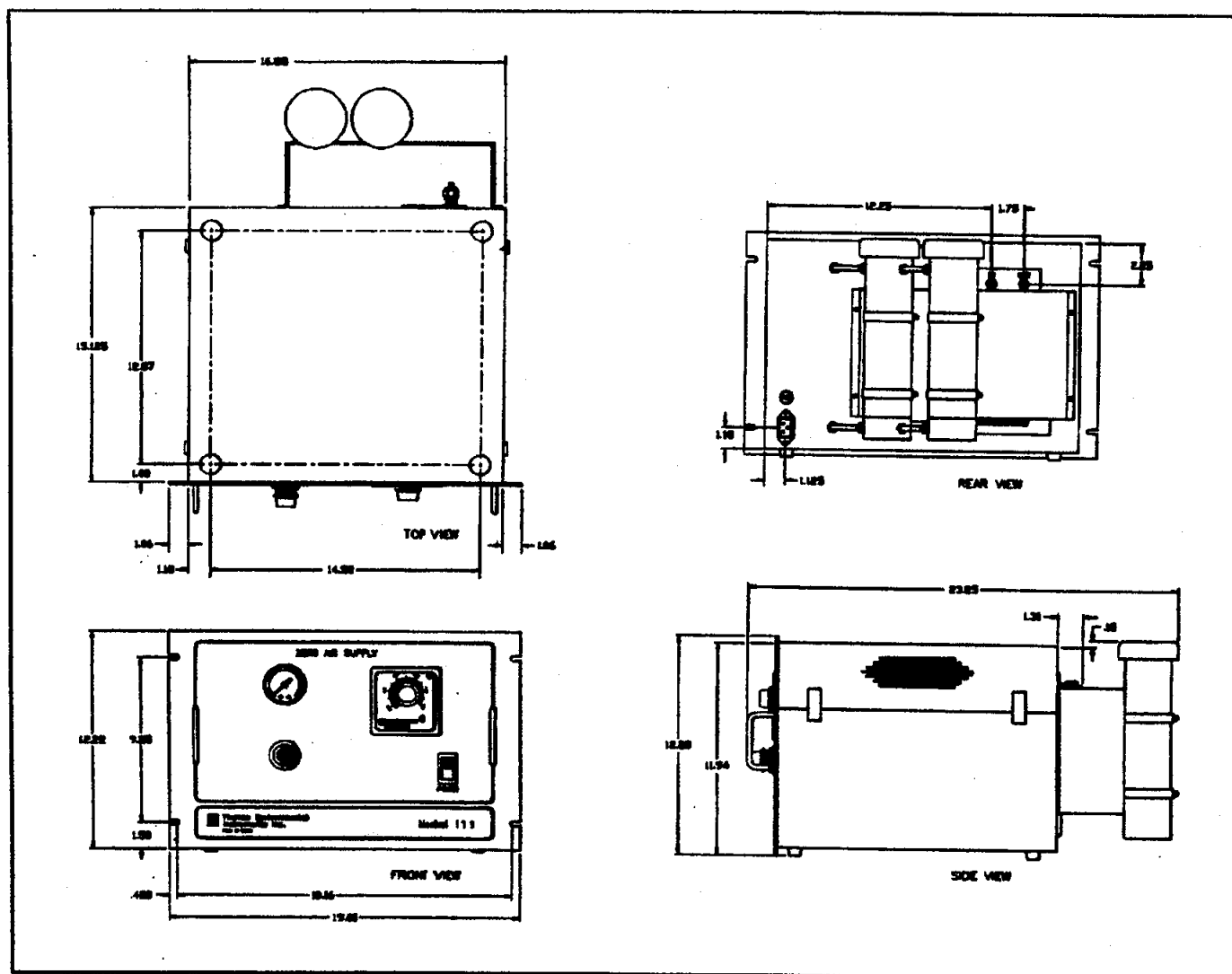
OPTIONS

- 001 Co-Reactor
- 002 Rack Mount Slides
- 005 20 LPM Compressor

MODEL 111 SPECIFICATIONS*

Pressure	10-30 PSI
Standard Flow Rate	0-10 L/min.
Water Vapor	0°C Dew Point
Dimensions	12.2"H x 19"W x 15.5"D Rack Mounting Standard
Weight	28 lbs.
Compressor Unit/Dimensions (Separate)	17"H x 12"W x 20"D
Weight	40 lbs.
*Flow Rate	0-10 LPM STD 0-20 LPM Optional

MODEL 111 DIMENSIONAL OUTLINE DRAWING



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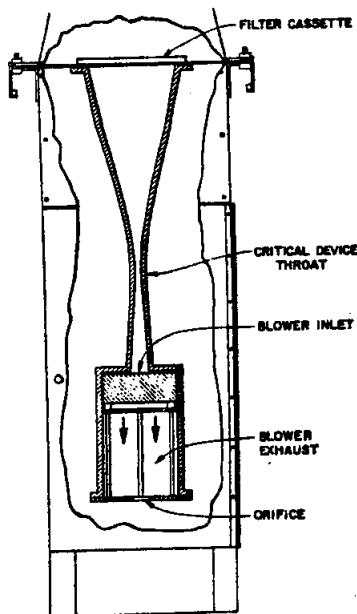
Introducing the Wedding & Associates Critical Flow High-Volume Sampler

Wedding 10 Micron Inlet
U.S. Patent No. 4,461,183

- Meets all FRM Tests, 40 CFR Part 53
- Wind Tunnel and Field Tested for over Five(5)Years
- Perfect Absorber, No Bounce Surface for Collected Particles

**Entire Upper Unit With
New Adapter Plates
Retrofits To Standard
High-Volume Bases**

- First New Base in 35 Years!
- Rugged, One-Piece, Air-Tight Construction



**State-Of-The-Art
Volumetric Flow
Controller***

- First New Technology in 10 Years!
- Critical Flow Device Needs No Calibration; No Electronics; No Moving Parts; Absolute Accuracy to Within $\pm 1.5\%$

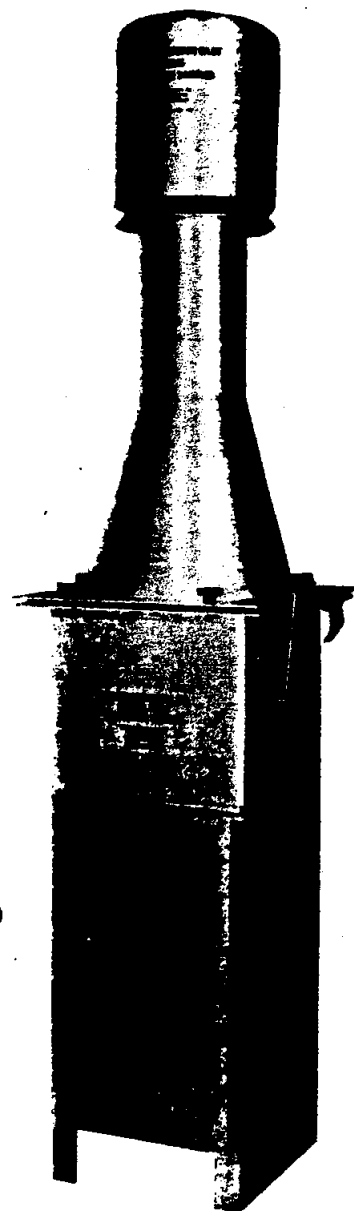
*Patent Applied For

- No Aerosolized Dust to Contaminate Your Filters as the Motor/Blower Discharges Through Six Side Exhaust Ports

For Information Concerning Availability and Pricing, Contact:

Wedding & Associates, Inc.

P.O. Box 1756 • Fort Collins, CO 80522 • (303) 221-0678



Performance of Wedding Inlet Meets FRM Requirements

Fig. 1.

Inlet
Performance
Curve

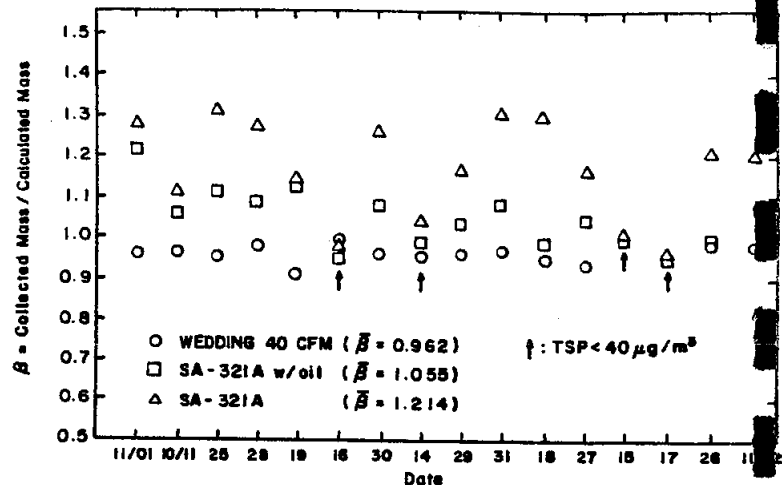
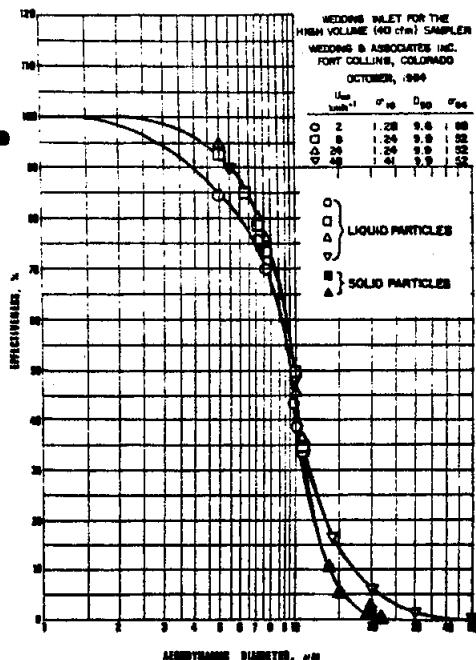


Fig. 2. Comparison of Collected to Calculated Mass Concentration (Wedding et al., 1985)

49 Fed. Reg., 10459, Proposed 40 CFR Part 53, Subpart D - Procedure for Testing Performance Characteristics of Methods for PM₁₀ contains provisions describing the required performance specifications for PM₁₀ samplers as:

Performance Parameter

Specification

Result and Reference

1. Sampling Effectiveness

A. Liquid Particles

Such that the expected mass concentration is within $\pm 10\%$ of that predicted by the ideal sampler.

The Wedding Inlet expected mass concentration is within $\pm 3.1\%$ (Wedding and Weigand, 1984, 1985), $\pm 2.8\%$ (Ranade and Kashdan, 1984) of that predicted by the ideal sampler.

B. Solid Particles

Sampling effectiveness is no more than 5% above that obtained for liquid particles of same size.

Referring to the performance curve (see Fig. 1) the Wedding Inlet has a sampling effectiveness $< 2.5\%$ (Wedding and Weigand, 1984, 1985), $< 2.0\%$ (Ranade and Kashdan, 1984) above that obtained for liquid particles of the same size.

2. 50% Cutpoint

$10 \pm 1 \mu\text{m}$ aerodynamic diameter

Referring to the performance curve (see Fig. 1), the Wedding Inlet has a 50% cutpoint of $9.6 \leq D_{50} \leq 9.9 \mu\text{m}$ (Wedding and Weigand, 1984, 1985) for 2, 8, 24 and 48 kmh^{-1} .

ADDITIONAL FRM TESTS NEEDED

A performance test not required in the as proposed FRM (49 Fed. Reg., 10459, Proposed 40 CFR Part 53, Subpart D) is a rigorous field test in which the validity of the wind tunnel determined effectiveness curves are substantiated.

A field test (Wedding et al., 1985) has been performed on the Wedding Inlet during the summer of 1984. Results given in Fig. 2 show that the mass collected by the Wedding Inlet is equal to the predicted mass within $\pm 5\%$ using the Wedding and Carney (1983) algorithm.

References:

- Wedding, J.B. and Weigand, M.A. (1984). "Sampling Effectiveness and 50% Cutpoint of Wedding 10 Micron Inlets: High Volume (40 CFM) and Dichotomous Sampler Inlets." Description of requirements and tests as set forth in Proposed 40 CFR, Part 50, Appendix J; 49 Fed. Reg. 10430 and Proposed 40 CFR, Part 53, Subpart D; 49 Fed. Reg. 10459. Test results submitted to: Director, Environmental Monitoring Systems Laboratory, Department E, United States Environmental Protection Agency, Research Triangle Park, North Carolina 27711.
- Wedding, J.B. and Weigand, M.A. (1985). "The Wedding Ambient Aerosol Sampling Inlet ($D_{50} = 10 \mu\text{m}$) for the High-Volume Sampler," Atmospheric Environment, 19, 535-538.
- Ranade, M.B. and Kashdan, E.R. (1984), "An Evaluation GMW Wedding PM-10 Size Selective Inlet," EPA Wind Tunnel Report No. 4.
- Wedding, J.B., Weigand, M.A., Kim, Y.J., and Lodge, Jr., J. (1985), "A Mass Distribution Monitor (MDM) for Atmospheric Particulate Matter," Aerosol Science & Technology (in review).
- Wedding, J.B. and Carney, T.C. (1983), "A Quantitative Technique for Determination of the Impact of Non-Ideal Ambient Sampler Inlets on Collected Mass," Atmospheric Environment 17, 873-882.

Wedding & Associates personnel have been leaders in the field of development, testing and modelling of ambient sampling inlets since 1975, having published 14 peer reviewed papers during that time principally in Environmental Science and

The Only Volumetric Flow Controller Presently Available: Wedding & Associates Critical Flow Device*

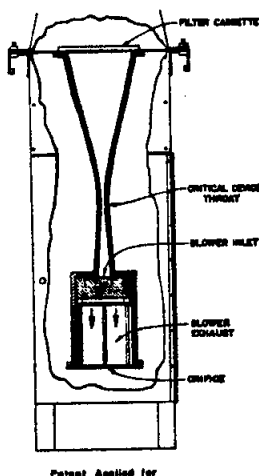
FRM Flow Control Requirements

49 Fed. Reg. 10432, proposed 40 CFR Part 50, Appendix J, presently requires that "... the sampler must be set to operate at and maintain the specified volumetric flow rate, measured under the actual ambient conditions of use...". This requirement for a volumetric flow controller at ambient conditions is not currently met by samplers employing setpoint mass flow transducers with errors in volumetric flow rate reaching 25-30% during routine operation as described by Wedding (1985). Wedding & Associates have thus developed a **Critical Flow Device*** to permit accurate and precise control of flow rate which will permit the collection of concentration data of high integrity. Size specific inlets such as PM_{10} systems employing fractionating devices whose performance depends on air velocity may experience substantial variations in sampler cutpoint values if operated using mass flow controllers. Additionally, the crucial value for total volume of air sampled used in the denominator when calculating ambient concentration levels will bear little resemblance to the actual volume sampled if the ambient sampler does not utilize a volumetric flow controller.

Calibration/Flow Audit Procedures

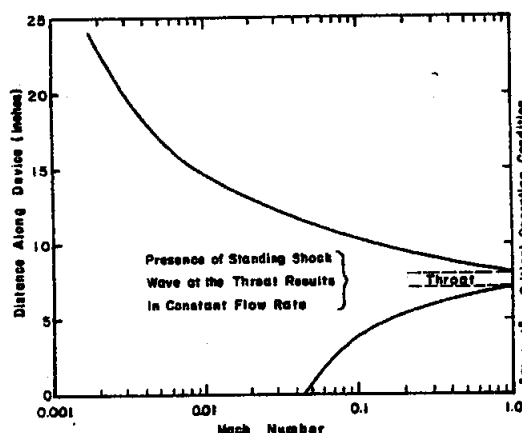
Historically, the calibration and subsequent periodic audits of the volumetric flow rate of ambient aerosol samplers have been time-consuming and consequently an expensive but necessary task required of field practitioners. The normal approach has been to utilize a flow transfer standard to provide an on-site flow rate calibration of the sampler. This has necessitated the dismantling of the flow control system, the removal of the inlet, a calculation procedure to correct for the temperature and pressure conditions of the day, and then a final adjustment of the flow control system for setpoint operation. Additionally, a pressure recorder has been used to provide an indication that during the sampling cycle the volumetric flow rate has not varied appreciably.

CRITICAL FLOW DEVICE



Wedding & Associates
Critical Flow Device*

Variation in Mach Number for the
Wedding & Associates
Critical Flow Device*



The device operates at
one, fixed flow rate: no
adjustments or calibration
required.

The Wedding & Associates Critical Flow Device* offers a revolutionary and unique flow control system in which the above described calibration and audit requirements can be reduced to an operation requiring minutes to perform. Using an NBS traceable pressure transfer standard a relationship is determined between the sampler calibration volumetric flow rate and the ratio of the sampler stagnation pressure (P_s) downstream of the filter to the ambient pressure (P_a). This relationship is then incorporated into a simple look-up table for use in the field. To calibrate the sampler in the field, provisions have been made for an in-situ measurement of the values, P_s and P_a . Utilizing the pressure transfer standard which is incorporated into a portable calibrator, a reading of P_s and P_a are realized in the field while the sampler is operating, which requires less than 1 minute to perform. By additionally reading the included precision thermometer and proceeding to the look-up table, one will know exactly the volumetric flow rate of the system.

Principle of Operation

The Wedding & Associates Critical Flow Device* implicitly utilizes the effect known as "choking." Definition of the critical state requires that the reference velocity is such that the Mach number is unity. The maximum in the curve of flow rate per unit area is uniquely related to the choking effect. For a given flow area, there is in subsonic flow a maximum initial Mach number which can be maintained steadily and the flow is then said to be "choked." When this condition occurs, a stable shock wave is created and maintained within the throat portion of the critical device. By maintaining a sufficient vacuum potential downstream of the throat, the presence of the shock wave limits the flow of air through the device to an absolute maximum. The flow rate is a unique and predictable function of the stagnation pressure and temperature, and said flow rate is unaffected by changes in the exit condition such as motor/blower speed or exit pressure. The unique energy recovery system of the Critical Flow Device* enables the usage of an inexpensive motor/blower. Thus, to operate the system you simply plug in the motor/blower assembly to line voltage and the flow remains constant in the choked condition with no adjustment required; no detailed calibration required, rather a one point check; no electronics to fail, and no moving parts. During a typical 24-hour sampling cycle, the volumetric flow rate will be known and accurate to within $\pm 1.5\%$.

Reference: Wedding, J.B., (1985) "Errors in Sampling Ambient Concentrations with Instruments Employing Setpoint Temperature Compensated Mass Flow Transducers," Atmospheric Environment, 19, 1219-1222.

*Patent Applied For

Wedding & Associates, Inc., is a High-Tech., Research & Development Firm

Wedding & Associates, Inc. is a High Technology, Research and Development Organization having expertise in the fields of aerosol science, fluid mechanics, ambient particle sampling, visible and infrared optics, remote sensing of airborne particles using optical methods and the use of state-of-the-art microcomputers for data acquisition and reduction.

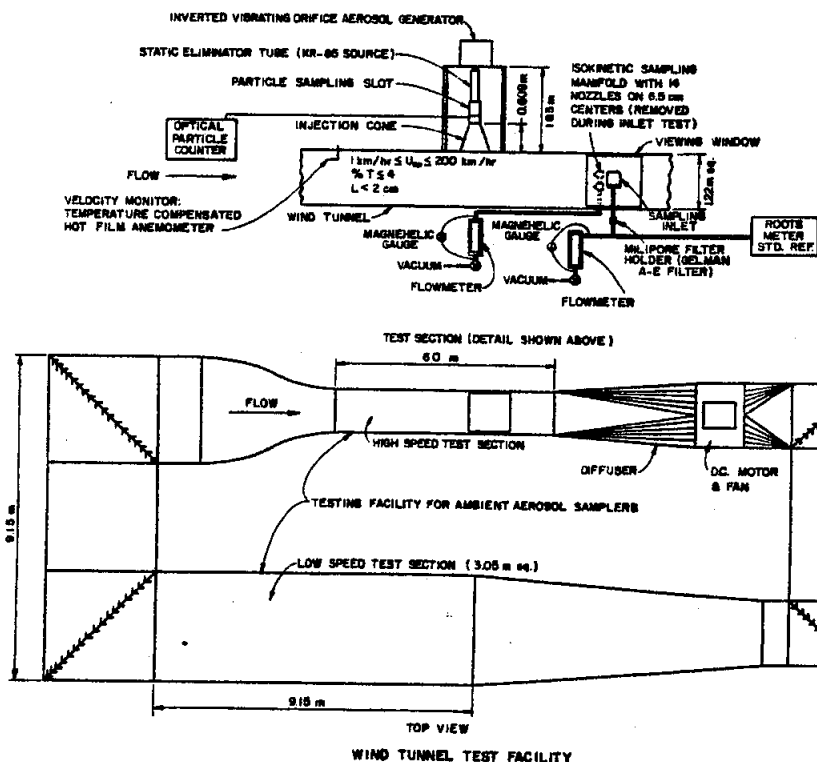
Dr. Wedding, as Professor of Civil Engineering at Colorado State University or President of Wedding & Associates, has been the Principal Investigator of numerous projects during the last 10 years with total budgets exceeding \$3.0 million. Dr. Wedding and his staff, to include Mr. Weigand and Dr. Kim, have completed the following projects of special interest:

- The design, fabrication and characterization of Ambient Aerosol Samplers (see references listed below).
- **Wedding 10 Micron Inlet** U.S. Patent No. 4,461,183
- The development of mathematical models to describe the behavior of large particles in the atmospheric boundary layer.
- The design, fabrication and testing of an Infrared Transmissometer.
- The design, fabrication and testing of computer controlled Particle Samplers.
- The design, fabrication and reduction to practice of a Critical Flow Device (Patent Applied For).
- The design, fabrication and characterization of a remote sensing Laser Particle Spectral Analyzer.
- The design of a multi-wavelength, multi-channel nephelometer to operate at both visible and infrared wavelengths.
- The design, fabrication and testing of a Mass Distribution Monitor for the accurate determination of Ambient Mass Concentrations.
- Development of an Automated Dry Deposition Monitor for Nitric Acid Concentrations.

Complete biographical histories of Wedding & Associates personnel are available upon request.

The Wedding & Associates Test Facility

- 10 years experience in Wind Tunnel Testing of Ambient Aerosol Samplers and Inlets
- Modelling of Particle Behavior
- Laser Spectrometry



Wedding, J.B., McFarland, A.R., and Cermak, J.E., "Large Particle Collection Characteristics of Ambient Aerosol Samplers", *Environmental Science & Technology*, Vol. 11, No. 4, pp. 387-390, April, 1977.

Wedding, J.B., Carney, T.C., and Stevens, R.K., "Ambient Aerosol Sampling: Past Problems, Current Goals and Recently Completed Wind Tunnel Tests of Hi-Volume Sampling", *International Journal of the Environment*, Vol. 3, No. 3, June, 1980.

Wedding, J.B., John, W., and Weigand, M., "Effectiveness of Sierra 244E Ambient Aerosol Sampler Inlet", *Environmental Science & Technology*, Vol. 14, No. 11, November, 1980.

Wedding, J.B., "Ambient Aerosol Sampling: History, Present Thinking and a Proposed Inlet for Inhalable Particles", *Environmental Science & Technology*, Vol. 16, No. 3, 1982.

Wedding, J.B., and Carney, T.C., "A Quantitative Technique for Determination of the Impact of Non-Ideal Ambient Sampler Inlets on Collected Mass", *Atmospheric Environment*, Vol. 17, Issue 4, pp. 873-882, April, 1983.

Wedding, J.B., Weigand, M.A., and Carney, T.C., "A 10 Micron Cutpoint Inlet for the Dichotomous Sampler", *Environmental Science & Technology*, Vol. 16, No. 9, pp. 602-606, September, 1982.

Wedding, J.B., Carney, T.C., Weigand, M.A., and Baumgardner, R.E., "The Wedding Ambient Aerosol Sampling Inlet for an Intermediate Flow Rate (4 cfm) Sampler", *Environmental Science & Technology*, Vol. 17, Issue 7,

Wedding, J.B., Weigand, M.A., Lodge, James P., "A Thoracic Particle Inlet ($D_{50} = 6$ microns, $D_{90} = 10$ microns) For the High-Volume Sampler", *Atmospheric Environment*, 17, 6, p. 1203-1204, June, 1983.

Wedding, J.B. and Weigand, M.A. (1985). "The Wedding Ambient Aerosol Sampling Inlet ($D_{50} = 10$ microns) for the High-Volume Sampler", *Atmospheric Environment*, 19, 3, 535-538.

Wedding, J.B., Weigand, M.A. and Kim, Y.J., (1985). "Evaluation of the Sierra-Andersen 10 micron Inlet for the High-Volume Sampler", *Atmospheric Environment*, 19, 3, 539-542.

Wedding, J.B., (1985), "Errors in Sampling Ambient Concentrations with Instruments Employing Setpoint Temperature Compensated Mass Flow Transducers", *Atmospheric Environment*, 19, 1219-1222.

Wedding, J.B., Lodge, Jr., J.P., and Kim, Y.J., (1985) "Comment on 'A Field Comparison of PM Inlets at Four Locations'", *J. APCA*, Vol. 35, No. 6.

Wedding, J.B., Kim, Y.J. and Lodge, Jr., J.P., "Analysis of the EPA Field Data: Rubidoux and Phoenix II", *J. APCA*, 1985 (in review).

Wedding, J.B., Weigand, M.A., Kim, Y.J. and Lodge, Jr., J.P., "A Mass Distribution Monitor (MDM) for Atmospheric Particulate Matter", *Aerosol Science and Technology* (in review), (1985).

F460 Wind Sensors

FEATURES:

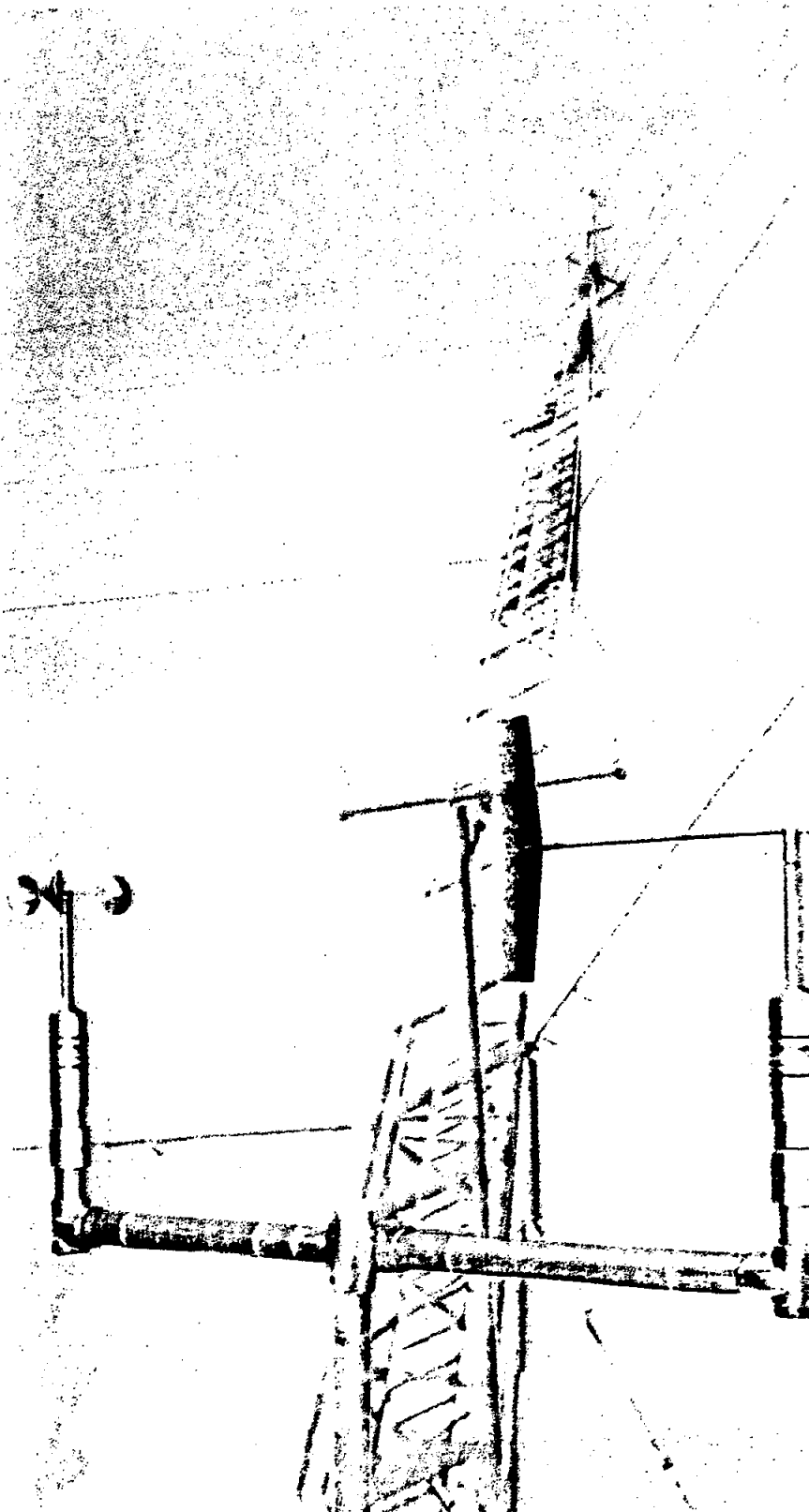
- Low Threshold
- High Survivability
- Excellent Dynamic Response
- CMOS Design
- Optional Internal/External Heaters

Climatronics' F460 Wind Sensors are capable of operation in virtually all weather conditions. Designed to meet the requirements of Specification No. F460-SP001 for the National Weather Service, the durability of these sensors make them ideal for multilevel tower installations. Although moderately priced, the F460 wind sensors offer the combination of low starting threshold, quick response, and high accuracy with excellent reliability over a wide range of operating conditions.

The F460 Wind Speed Sensor, P/N 100075, monitors the wind speed with a three-cup anemometer assembly. A 30-hole chopper with an LED photochopper device provides a frequency output directly proportional to the wind speed. Traceability to NIST (formerly NBS) is available as an option for each anemometer cup assembly by comparison testing against an NIST transfer standard in our wind tunnel test facility.

The F460 Wind Direction Sensor, P/N 100076, consists of a counter-balanced, lightweight vane and a precision, low-torque, highly-reliable potentiometer to yield a voltage output proportional to the wind direction. Once properly oriented on the keyed cross-arm mount at a particular installation, the wind direction sensor may be removed or replaced without requiring reorientation.

Installation of the sensors is a simple matter of either fastening each sensor to separate pipes of 1 1/4 inch IPS or attaching both sensors to Climatronics' prewired crossarm, P/N 100487, which in turn mounts on a 1 1/4 inch IPS pipe. Internal sensor electronics are accessed by sliding off the outer aluminum sleeve. Optional internal and external heaters for both sensors are available. The Internal Heaters, P/N 101263, consume approximately four watts of power and operate on a continuous basis, while the External Heaters, P/N 101235, consume approximately 20 watts of power and are thermostatically controlled.



Signal conditioners for the F460 sensors are available in modular form with a variety of full scale ranges, engineering units, outputs, and several other options. Please consult the Modular Meteorological System (MMS) and the Remote Meteorological System (RMS) data sheets for more details.

The sensors may be directly interfaced either to Climatronics' IMP-800 series of digital data acquisition

units or almost any of the currently available data loggers/data acquisition units.

The Component Anemometer, P/N 101284, can be used in conjunction with the F460 System to measure the vertical component of the wind. Consult the Orthogonal (UVW) Wind Sensor data sheet for additional details.

SPECIFICATIONS:

PERFORMANCE:

Signal Output

Accuracy

Threshold

Distance Constant

Damping Ratio

Operating Range

F460 Wind Speed (P/N 100075)

2.0 Vpp into 2K ohms,
frequency proportional to wind speed
0.15 mph (± 0.07 m/s) or $\pm 1.0\%$
of true air speed (whichever is greater)
0.5 mph (0.22 m/s)
Vinyl: 5 ft. (1.5 m) of air max.
Stainless Steel: 8.0 ft. (2.4 m) of air max.

0-125 mph (0-56 m/s)

F460 Wind Direction (P/N 100076)

Variable DC voltage magnitude
proportional to wind direction
 $\pm 2^\circ$

0.5 mph (0.22 m/s)
2.95 ft. (.9 m) of air max.

0.4 at 10° initial angle of attack
0 to 360°

ELECTRICAL:

Power Requirements*

+ 12 VDC at 1 mA nominal

Max. 1 mA through 10K ohms

PHYSICAL:

Size

Weight

Turning Radius

Operating Temperature

Use with Signal

Conditioner

2.25" (5.7 cm) max. diameter
11.5" (29.2 cm) high
Less than 2 lbs. (0.9 Kg)
3.75" (9.5 cm)
-40 to 140° F (-40 to 60° C)
P/N 100163 (MMS)
P/N 100778 (RMS)

2.25" (5.7 cm) max. diameter
11.5" (29.2 cm) high
Less than 2 lbs. (0.9 Kg)
16.5" (41.9 cm)
-40 to 140° F (-40 to 60° C)
P/N 100163 (MMS)
P/N 100779 (RMS)

CROSSARM:

P/N 100487

Length

Weight

Mounting

45" (114.3 cm)
7 lbs. (3.2 Kg)
1.66" (4.2 cm)

O.D. pipe (1 1/4" IPS)

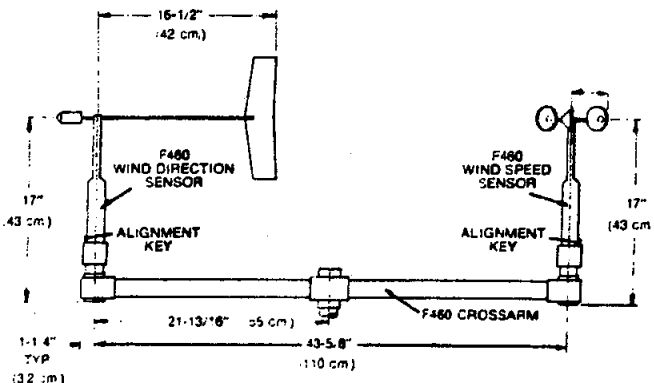
HEATER:

P/N 101263 Internal

P/N 101235 External

12 VDC, 2 watts per sensor
115 VAC/60 Hz, 20 watts per sensor

*Proper power provided by signal conditioner.





CORPORATION

Temperature Sensors

- Maintenance Free
- Versatile
- Highly Accurate
- Durable

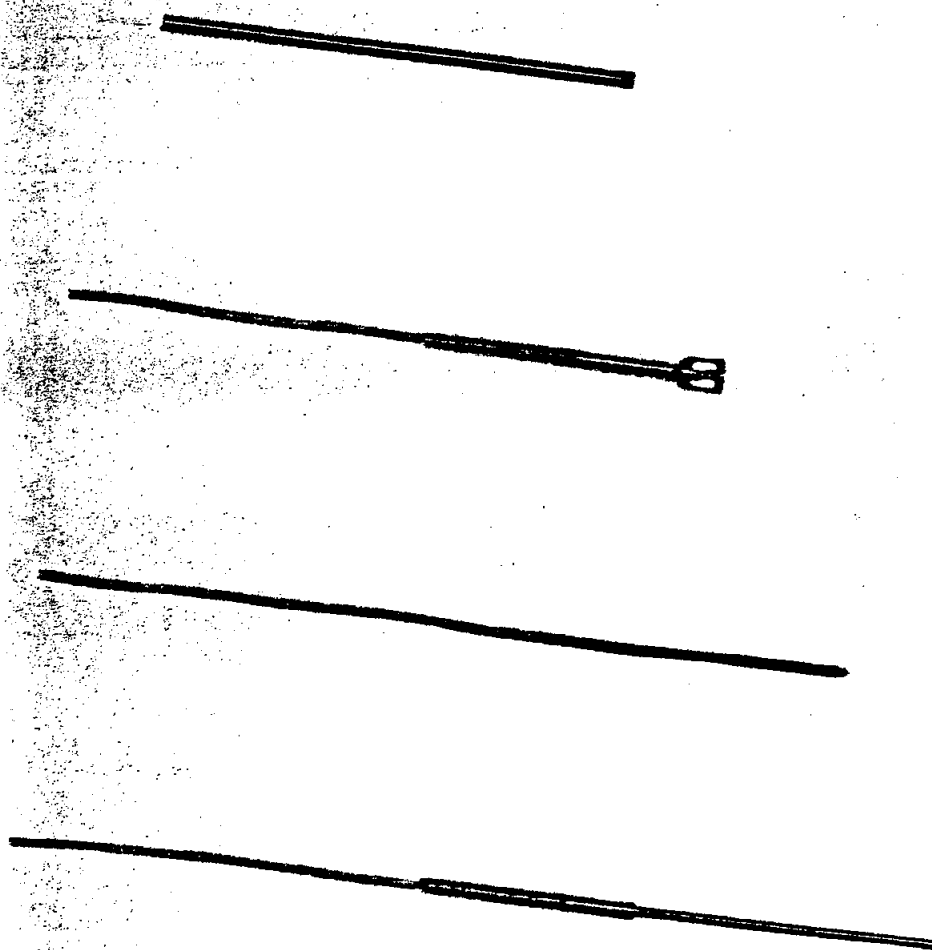
Capable of meeting virtually any ambient measurement need, Climatronics' temperature sensors are accurate, durable, linear over a wide range, can be provided with NBS traceable calibration, and are well-matched for high accuracy delta temperature applications.

The Air, Water/Soil, and Expanded Range Sensors encase a thermistor bead in a stainless steel or vinyl sheath. This casing, combined with Climatronics' temperature shield, gives the thermistor bead protection from solar radiation, precipitation, and corrosive, airborne particles. Such configurations transfer heat as rapidly as possible, yielding a typical time constant of 3.6 s. When direct exposure of the thermistor to the media being measured is permissible, our Fast Response Sensor reduces the time constant to a minimal 0.6 s.

A second type of sensor, Platinum 4-Wire, operates on the principle that electrical resistance of a pure metal increases with temperature. Platinum's superior linearity, stability, sensitivity and resistance to corrosion, make it an ideal practical choice. The unit's four-wire design automatically compensates for possible lead resistance errors, and it comes standardly supplied with certified NBS traceability.

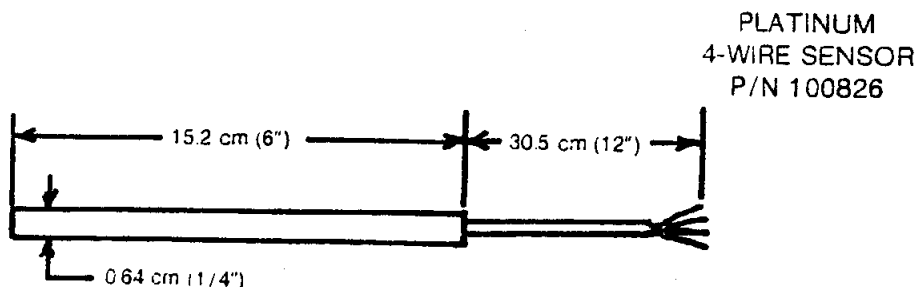
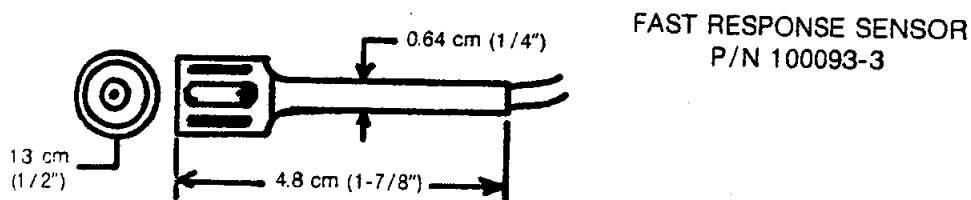
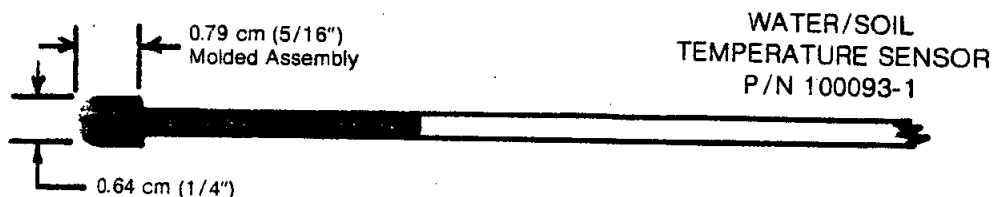
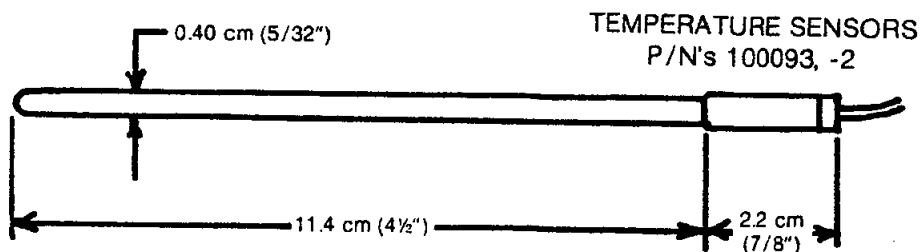
Sensors install easily in Climatronics' temperature shields. The TS-10 Motor Aspirated Shield, P/N 100325, regulates air flow past the sensor (as discussed in the TS-10 data sheet) while the Naturally Aspirated Shield, P/N 100552, relies on ambient air flow or convection for sensor aspiration.

Please consult the Modular Meteorological System (MMS) or Remote Meteorological System (RMS) signal conditioner data sheets for the proper temperature sensor interface to use with the sensor of your selection.



Specifications

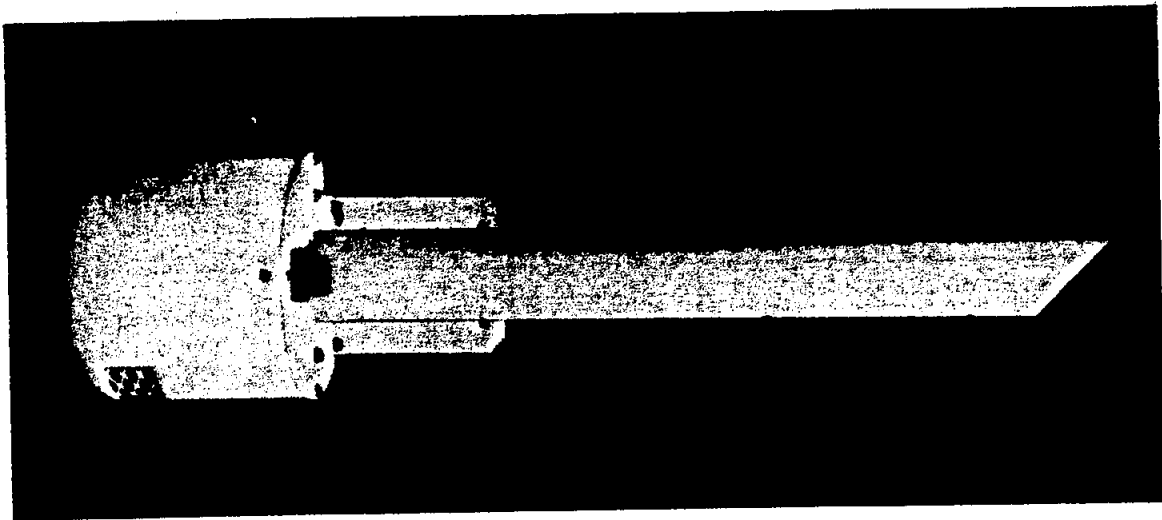
	Air, Water/Soil P/N's 100093, 100093-1	Expanded Range P/N 100093-2	Fast Response P/N 100093-3	Platinum 4-Wire P/N 100826
Accuracy	$\pm 0.15^{\circ}\text{C}$ ($\pm 0.27^{\circ}\text{F}$) over full range	$\pm 0.10^{\circ}\text{C}$ ($\pm 0.18^{\circ}\text{F}$) over full range	$\pm 0.15^{\circ}\text{C}$ ($\pm 0.27^{\circ}\text{F}$) over full range	$\pm 0.1^{\circ}\text{C}$ ($\pm 0.18^{\circ}\text{F}$) over full range
Range	-30.0° to 50.0°C (-22.0° to 122.0°F)	-50.0° to 50.0°C (-58.0° to 122.0°F)	-30.0° to 50.0°C (-22.0° to 122.0°F)	-50.0° to 50.0°C (-58.0° to 122.0°F)
Time Constant	3.6 s	3.6 s	0.6 s	5.5 s
Interchangeability	$\pm 0.15^{\circ}\text{C}$ ($\pm 0.27^{\circ}\text{F}$)	$\pm 0.10^{\circ}\text{C}$ ($\pm 0.18^{\circ}\text{F}$)	$\pm 0.15^{\circ}\text{C}$ ($\pm 0.27^{\circ}\text{F}$)	$\pm 0.25^{\circ}\text{C}$ can be compensated
Linearity	$\pm 0.16^{\circ}\text{C}$ ($\pm 0.29^{\circ}\text{F}$)	$\pm 0.08^{\circ}\text{C}$ ($\pm 0.25^{\circ}\text{F}$)	$\pm 0.16^{\circ}\text{C}$ ($\pm 0.29^{\circ}\text{F}$)	$\pm 0.05^{\circ}\text{C}$ included in accuracy
Leads	3	4	3	4
Size	0.64 cm dia x 11.4 cm long ($\frac{1}{4}''$ x $4\frac{1}{2}''$)	0.64 cm dia x 11.4 cm long ($\frac{1}{4}''$ x $4\frac{1}{2}''$)	0.64 cm dia x 4.8 cm long w/shield; otherwise 1.3 cm long ($\frac{1}{4}''$ x $1\frac{1}{8}''$) w/shield; other- wise $\frac{1}{2}''$)	0.64 cm dia x 15.2 cm long ($\frac{1}{4}''$ x $6''$)



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Bohemia, New York 11716
(516) 567-7300
TLX: 5101007669
CAY: 15151 527 7502



TS-10 ASPIRATED TEMPERATURE SHIELD



The Model TS-10 is a motor aspirated temperature shield which is designed to continuously sample the ambient air without effects from solar radiation. The shield can be supplied with a precision linear thermistor sensor and translation circuitry to convert the output to a DC voltage suitable for recording. Standard accuracy is $\pm 1^\circ\text{F}$ from -30° to $+120^\circ\text{F}$. Overall length is 42 inches.

Sensor:	Thermocouple, Resistance Bulb. Thermistor or TD-10 digital sensor.
Error:	0.2° or less under radiation of $1.6 \text{ gm-cal/cm}^2/\text{min}$.
Temp. Range:	-65° to 150°F .
Power:	115v 50-60 Hz. AC Single Phase
Model TS-10W:	Same as Model TS-10 with the addition of an aspirated shield to mount a standard Weather Bureau Dew cell.
Model TS-10R:	Same as Model TS-10 for Relative Humidity Sensor.
Model TS-10WA:	Same as Model TS-10 with the addition of an aspirated shield to mount the Model DP-10 dew cell.

CLIMATRONICS
CORPORATION

EPPLEY BLACK AND WHITE PYRANOMETER

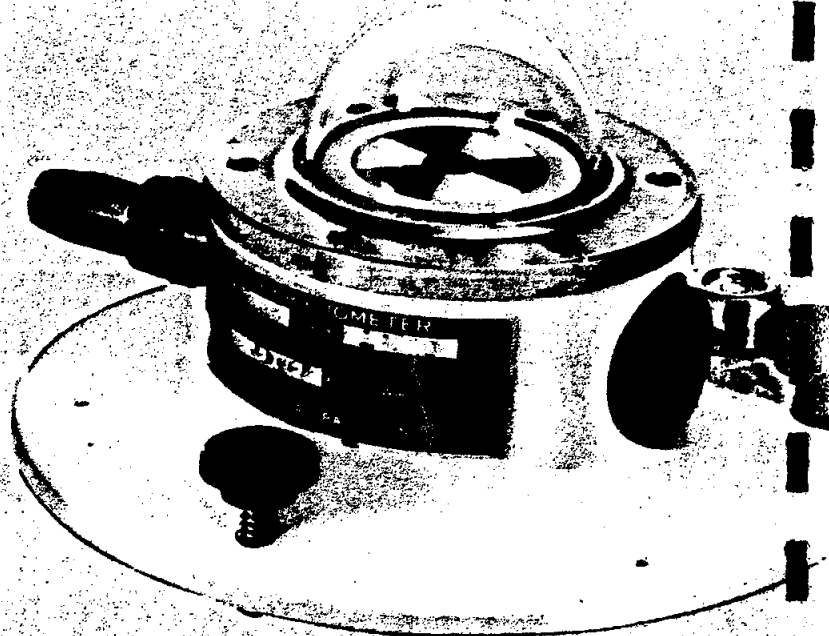
FEATURES:

- Differential Thermopile
- Precision Ground Optical Glass Hemisphere
- Built-in Temperature Compensation

Climatronics' Eppley Black and White Pyranometer is a development of the well-known Eppley 10 and 50 junction 180° pyrliometer originally introduced by Kimball and Hobbs in 1923. The detector is a differential thermopile with the hot-junction receivers blackened and the cold-junction receivers whitened.

The element is of radial wirewound-plated construction with the black segments coated with 3M black and the white with Barium Sulfate. Built-in temperature compensation with thermistor circuitry is incorporated to free the instrument from the effects of ambient temperature. A precision ground optical glass hemisphere of Schott glass WG295 uniformly transmits energy from 285 to 2.800 millimicrons. This hemispherical envelope seals the instrument from the weather but is readily removable for instrument repair. The cast aluminum case carries a circular spirit level and adjustable leveling screws. Also supplied is a desiccator which can be inspected readily.

The detector can be used on a tilt or at any orientation with no effect on sensitivity. A calibration certificate traceable to the World Radiation Reference is included with conversion factors for different energy units.



SPECIFICATIONS:

SENSITIVITY: 11 microvolts/watt meter⁻² approx.

IMPEDANCE: 350 ohms approx.

TEMPERATURE DEPENDENCE: +/- 1.5 percent constancy from -4° to +104°F (-20 to +40°C)

LINEARITY: +/-1 percent from 0 to 1400 watts meter⁻²

RESPONSE TIME: 5 seconds (1/e signal)

COSINE RESPONSE: +/-2 percent from normalization 0-70° zenith angle +/-5 percent 70-80° zenith angle

ORIENTATION: no effect on instrument performance

MECHANICAL VIBRATION: capable of withstanding up to 20 g's

CALIBRATION: integrating hemisphere (approx. 1 cal cm⁻² min⁻¹, ambient temperature +77°F (+25° C)

SIZE: 5 3/4 in. diameter, 2 3/4 in. high (14.6 cm diameter, 7 cm high)

WEIGHT: 2 pounds (.91 Kg)



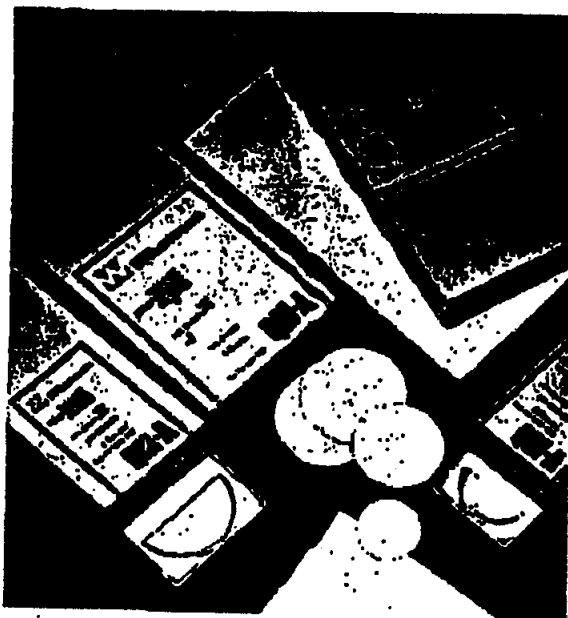
140 Wilbur Place, Airport International Plaza
Bohemia, NY 11716 USA (516) 567-7300
Telex: 510-100-7669 Fax: (516) 567-7585



RECYCLE
0591



TECHNICAL DATA ON

ULTRA-PURE QM-A
QUARTZ FILTERS

QM-A QUARTZ TECHNICAL DATA

Basis Weight	85 gm/m ²
Thickness	0.45 mm
Particle retention efficiency	99.999% retention (0.6 µm particles at 5cm/sec F.V.) or 0.001% penetration
Dry Tensile (1.5 cm wide strip)	250 - 300 g
Maximum Temperature	500° C
Air flow rate	800 litres/min (for 400 cm ² filter area at Δp = 20 mm Hg)

N.B. 400 cm² is effective filtration area of 8" x 10" sheet

CHEMICAL PURITY

Element	p.p.m.	Micrograms per sheet (8 x 10 in)
Cd	0.23	1
Co	1.1	5
Cr	1.6	7
Cu	3.4	15
Fe	23.0	100
Mn	0.48	2
Ni	3.4	15
Pb	2.3	10
Zn	10.2	50

All values typical subject to normal manufacturing tolerances.

PUBLICATION NO 680 QM-A A

QM-A. THE NEW ULTRA-PURE
QUARTZ FILTER FROM WHATMAN
FOR AIR SAMPLING.

Whatman now introduce QM-A, an ultra-pure quartz (SiO₂) microfibre filter for the most exacting work in air pollution monitoring. QM-A is heat-treated and entirely binder free and only a small amount (5%) of conventional borosilicate glass microfibre are added for papermaking purposes.

ULTRA-PURE - HIGH FLOW RATES

Ultra-pure QM-A is extremely low in heavy metal content, whilst offering the high flow rates and filtration efficiencies of conventional borosilicate glass microfibre filters. Trace level determinations in particulates can now be carried out with the utmost accuracy.

LOW IN ALKALINE EARTH METALS

Whatman QM-A contains virtually no alkaline earth metals and is therefore recommended for sampling and subsequent analysis of environments where acidic gases such as SO₂ and NO_x are encountered. 'Artifact' production of sulphates and nitrates on the filter, is, thus, virtually eliminated with QM-A and critical analyses can now be conducted free from inaccuracies caused by artifact production with glass microfibre filters.

APPLICATIONS

Whatman QM-A is suitable for ambient and high temperature (max 500° C) air sampling of environments such as stacks, flue outlets and aerosols. Being ultrapure and containing low levels of elements important in pollution studies, Whatman QM-A is the filter of choice for critical analyses and trace level determinations, and it is especially suitable for analytical techniques such as atomic absorption spectroscopy and flame emission spectrophotometry.

The low background levels of heavy metals in QM-A also make it suitable for X-ray fluorescence techniques and neutron activation analyses

MINIMAL WEIGHT LOSS

QM-A is heat treated after manufacture to remove bound moisture and trace organic impurities and to ensure minimal weight loss on further heating. For accurate gravimetric results, as with any medium, it is essential, both before and after sampling, to condition the filter carefully before weighing.

AVAILABILITY

Standard Sizes	Cat. No.
Circles: 3.2 cm dia	1851 032
3.7	1851 037
4.7	1851 047
5.5	1851 055
Sheets: 20.4 x 25.4 cm (8 x 10 in)	1851 985

COMPARISON OF PHYSICAL CHARACTERISTICS AND CHEMICAL PURITY OF WHATMAN QM-A QUARTZ MICROFIBRE FILTERS, EPM1000, GF/A AND GRADE 41

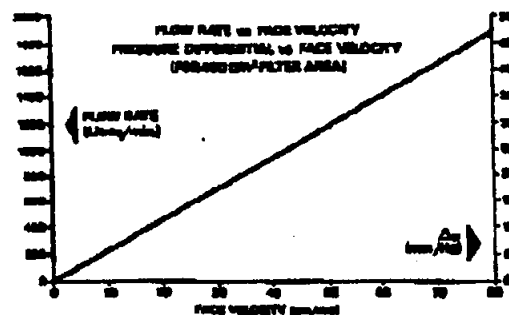
(1) PHYSICAL CHARACTERISTICS:

	QM-A	EPM1000	GF/A	Gr. 41
Composition	Quartz Microfibre	Glass Microfibre	Glass Microfibre	Cellulose (Cotton Linters)
Basic weight, g/m ²	85	80	80	85
Thickness (mm)	0.45	0.43	0.38	0.21
Dry Tensile (g)	230-300	742	420	2400
Sodium Flame Resistance (Nella) (%)	99.999	99.999	99.999	74
ΔP (mm Hg)	3	3	3	3
Temperature Resistance (Max. °C)	500	500	600	200
Air Flow at $\Delta P = 2$	120	120	120	120
Air Flow at $\Delta P = 20$	900	780	800	1150

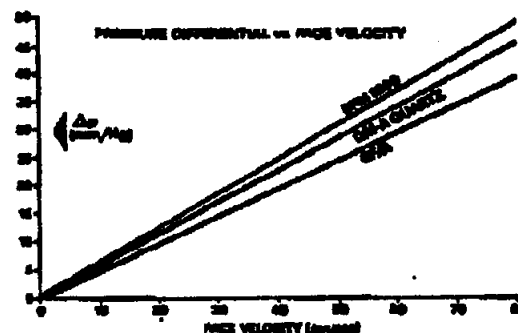
NOTES

- * All values are "typical" and subject to normal manufacturing tolerances.
- * Tensile 1.5 cm wide strip.
- * Sodium flame penetrant test to BS 4429 at values at 500/Sec F.V.
- * Pressure differential across filter at 500/Sec F.V.
- * Measured in litres/min for air below for 400 cm² area assuming no flow restriction imposed by holder.
- * Key F.V. = Face Velocity
- * ΔP figures at higher F.V.'s than 5 cm/sec vary considerably with grade of filter and Air Pollution Monitoring brochure for graphs of ΔP vs F.V.

QM-A QUARTZ FILTER FLOW RATE



COMPARISON OF QM-A QUARTZ, EPM1000 AND GF/A



(2) CHEMICAL PURITY Concentrations given in $\mu\text{g}/\text{sheet}$ (8" x 10") and in p.p.m.

Element	QM-A		EPM1000		GF/A		GRADE 41	
	$\mu\text{g}/\text{sheet}$	p.p.m.	$\mu\text{g}/\text{sheet}$	p.p.m.	$\mu\text{g}/\text{sheet}$	p.p.m.	$\mu\text{g}/\text{sheet}$	p.p.m.
Cd	1.8	0.22	2.1	0.6	2.7	1.0	ND	ND
Cs	4.8	1.1	1.24	0.3	2.7	1.0	ND	ND
Cr	7.8	1.8	4.96	1.2	0.95	0.2	1.3	0.3
Cu	14.8	3.4	2.5	0.7	16.4	6.0	1.75	0.4
Fe	100	22	105	26	276	180	28.3	8.0
Mn	2.8	0.48	4.86	1.2	21.3	8.0	<0.22	<0.05
Ni	14.9	3.4	14.4	2.8	16.4	6.0	ND	ND
Pb	10.0	2.3	10.3	2.5	27	10	0.8	0.2
Zn	80	18.2	106	26	ND	ND	2.6	0.6

KEY: ND = NOT DETERMINED

NOTES Cellulose Data obtained from analysis of ash. Glass Data obtained from extraction under acid conditions.



Whatman

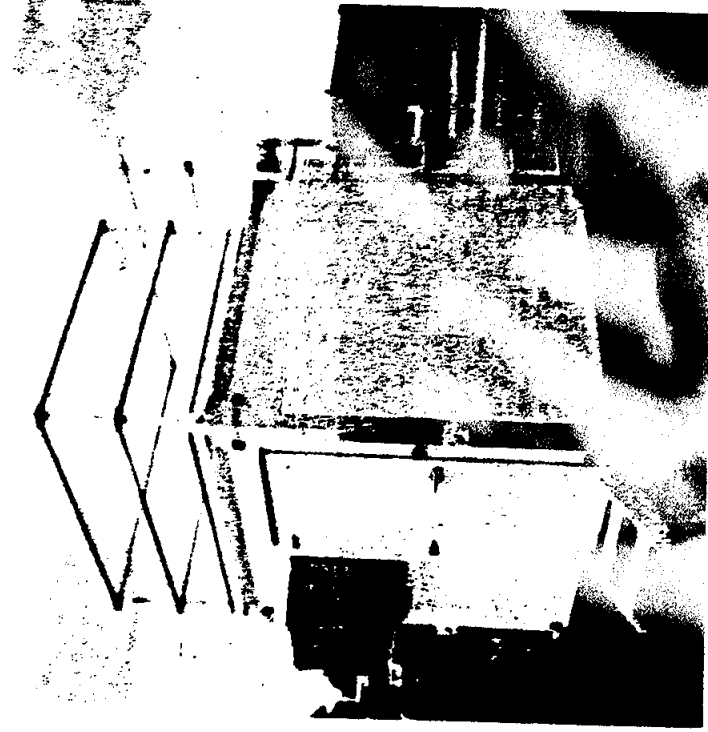
PAPER DIVISION

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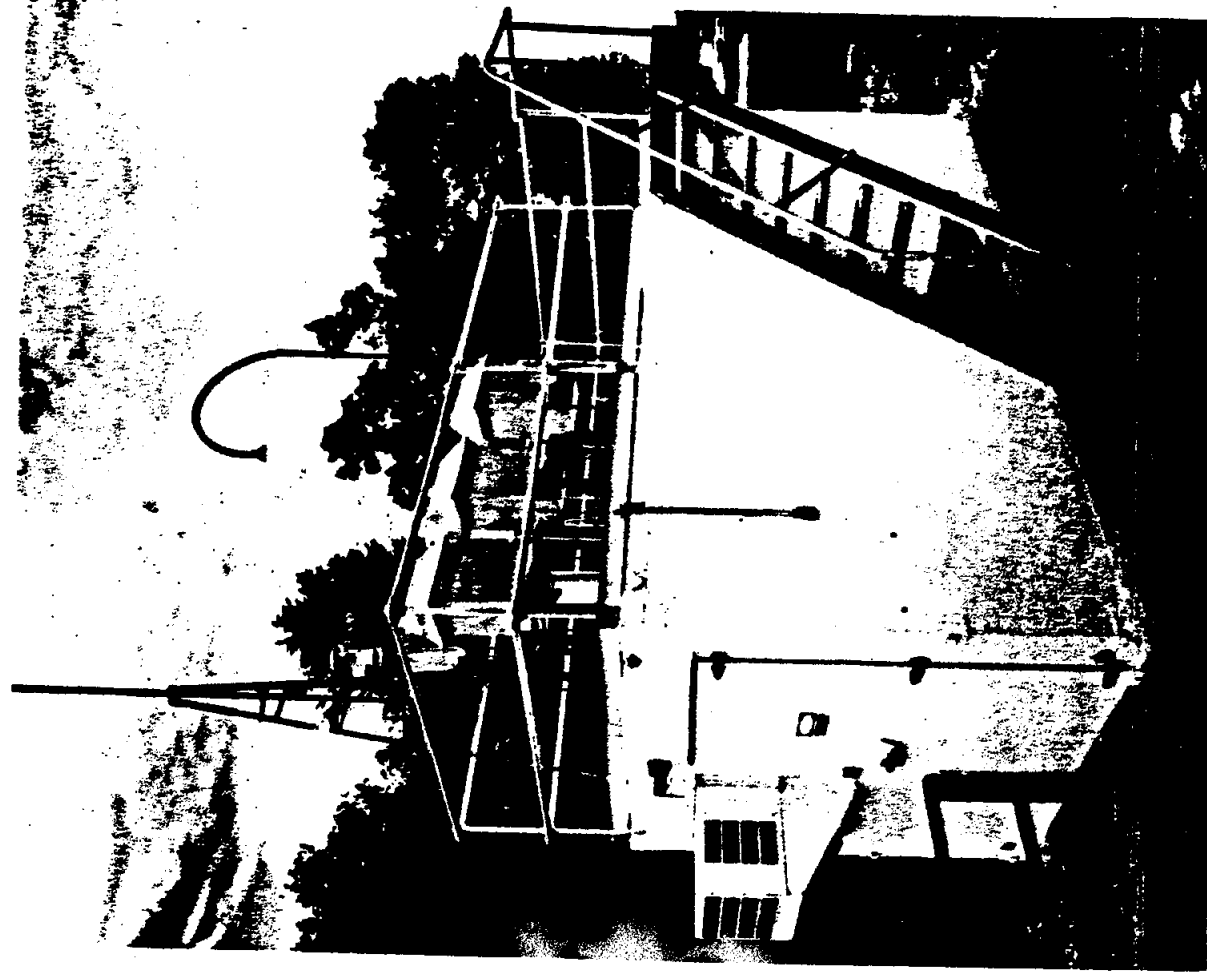
Mobile Shelters

— CUSTOM DESIGNED AND BUILT FOR EVER EXPANDING APPLICATIONS —
— HERE ARE A FEW EXAMPLES —

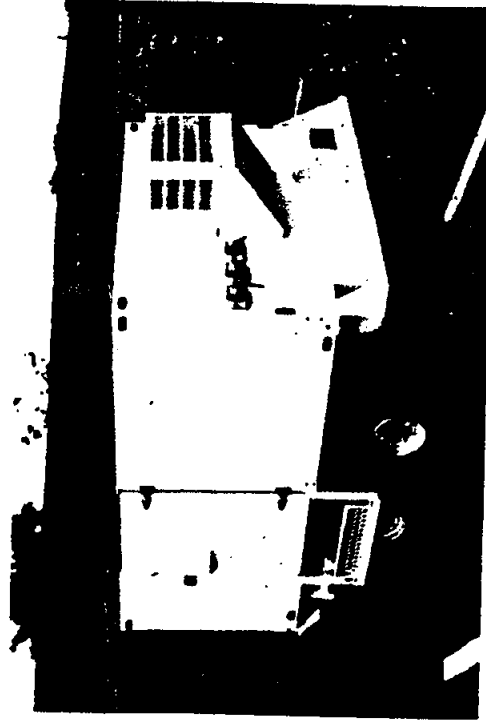
ENVIRONMENTAL MONITORING



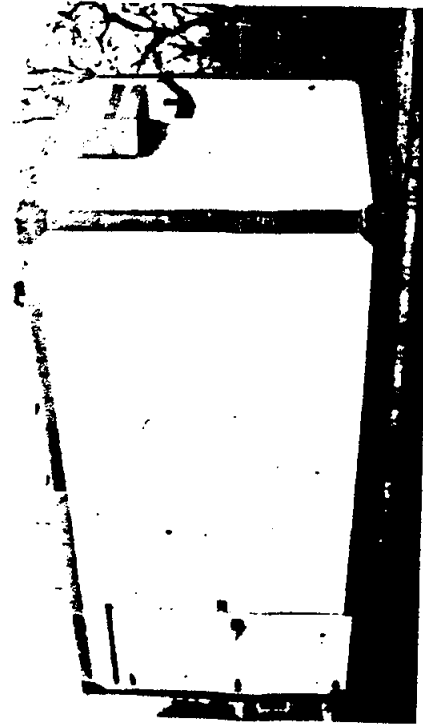
8 ft. Shelter
Air Monitoring



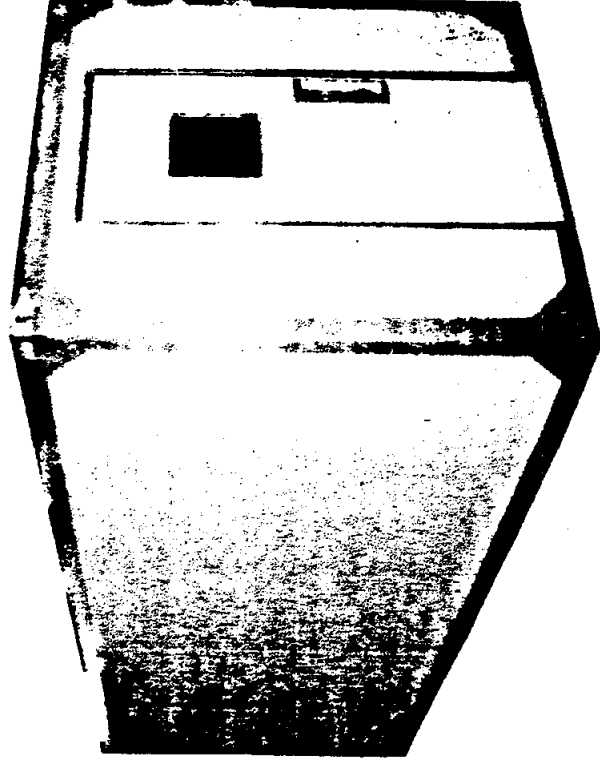
16 ft. Shelter Deployed
Air Monitoring



Underground Shelter
for Environmental Monitoring
in Mine Shafts
Separate Undercarriage



18 ft. Train Hot Bearing
Detector Shelter
Houses Diesel Powered Electric
Generator and Instruments

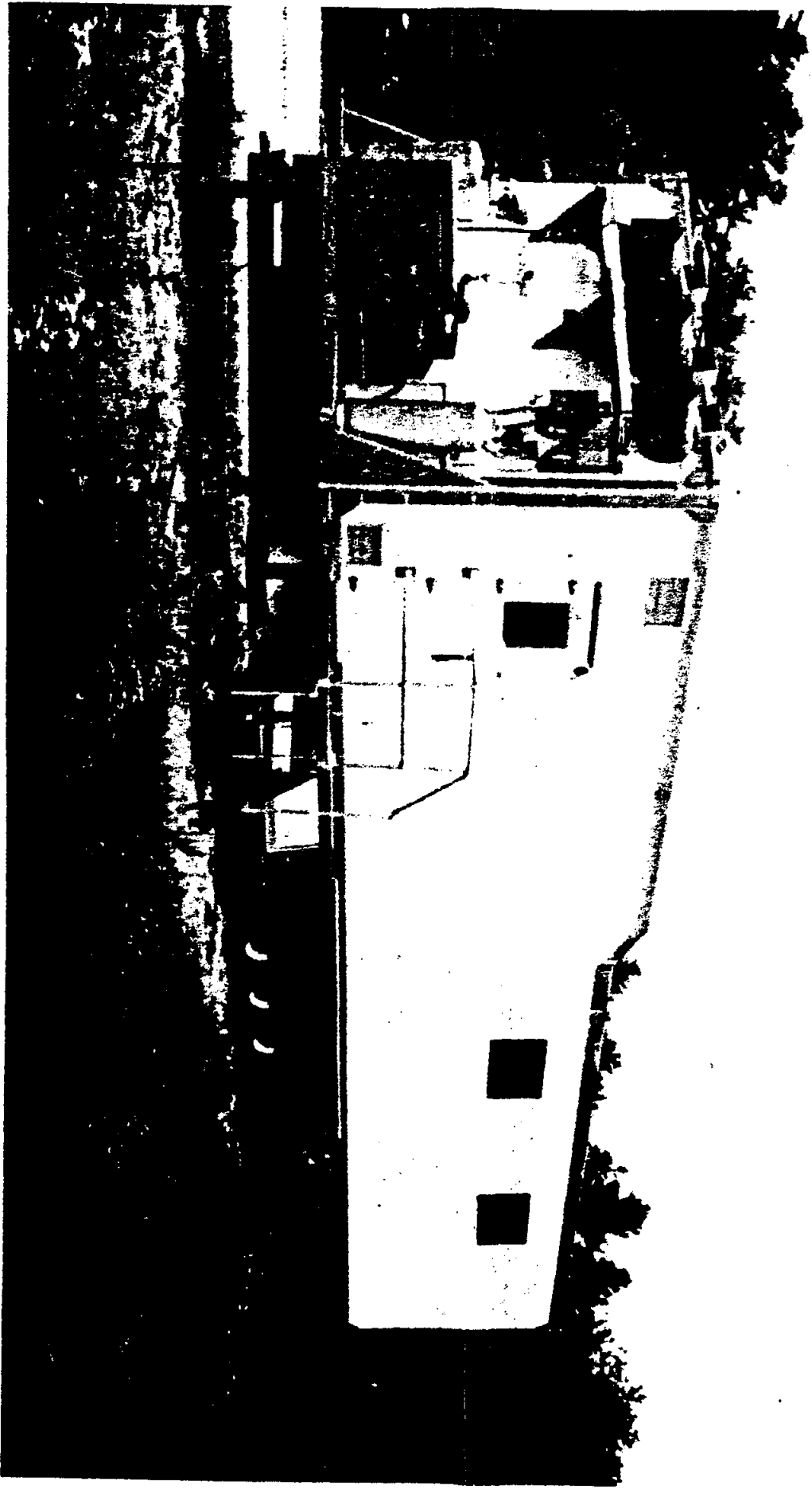


20 ft. "ISO" Shelter
Adapted for In-Process
Natural Gas Monitoring
Middle East Environment

EKTO MANUFACTURING CORP.
P. O. Box 449
Sanford Industrial Estates
Sanford, Maine 04073



Tel. 207 324-4427



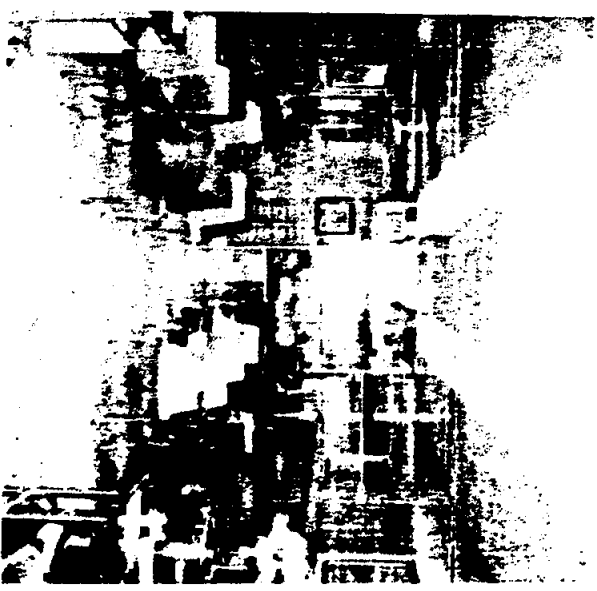
MOBILE LEARNING CENTER
12 ft. w x 12 ft. h x 60 ft. lg.

Used for Nutrition Teaching Facility
— 20 Student Capacity

Self-Contained Unit - LPG
Powered Electric Generator
and Environmental Control Unit.
Own Fresh and Waste Water
Holding Tanks — Steam Generator
and Many More Features.



KITCHEN SECTION



CLASSROOM SECTION



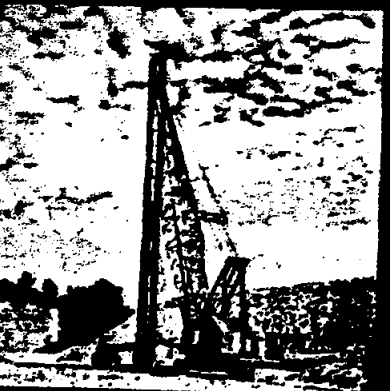
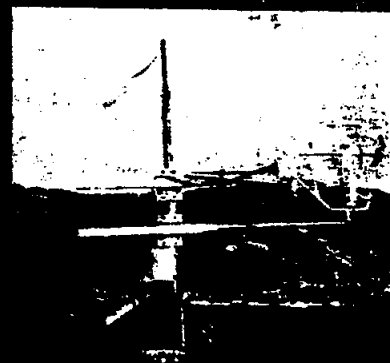
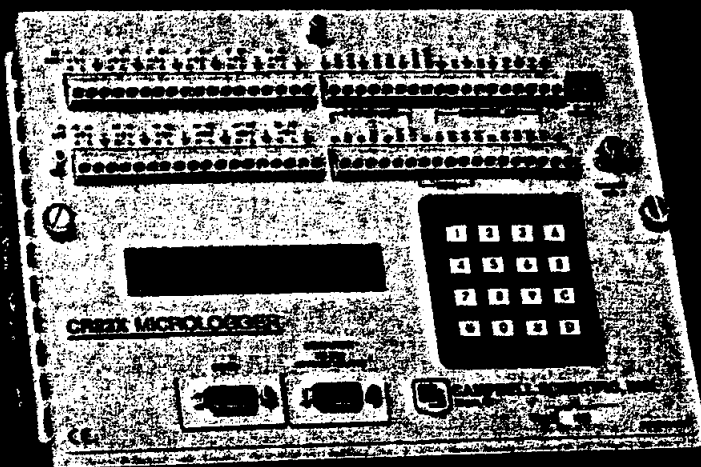
MOBILE MISSILE TRACKING STATION
10 ft. w x 12 ft. h x 30 ft. lg.

for Naval Research Lab.
Separate All Aluminum
Undercarriage to Resist
Severe Environmental Conditions.

LET US HELP ENGINEER AND DESIGN YOUR NEXT
UNUSUAL, MOBILE OR STATIONARY ENCLOSURE!

CR23X Micrologger

A Portable, Rugged, Powerful Data Acquisition System

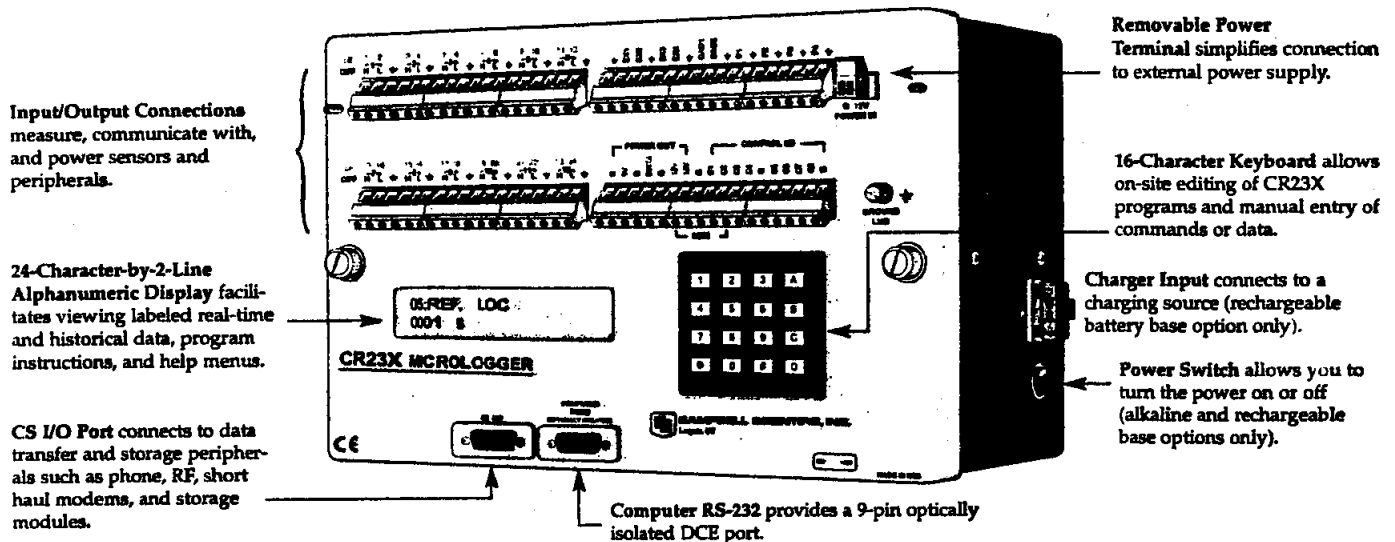


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System Description

The CR23X Micrologger is a compact, rugged, powerful datalogger. Housed in a portable, self-contained package, the Micrologger consists of measurement and control electronics, communication ports, keyboard, display, power supply, and carrying handle. Minimum power requirements allow extended field use from a dc voltage source.



Design Features

The CR23X measures most sensor types directly, communicates via modems, reduces data, controls external devices, and stores both data and programs in either non-volatile Flash memory or battery-backed SRAM. The standard 2 Mbyte memory stores 1,000,000 data points in two final storage areas. With the 4 Mbyte option, the CR23X can store over 2 million data points.

Two operating system options are available. The array-based operating system stores arrays of data at specified intervals or when some other set condition has been met. The table-based operating system allows you to group and store like data in separate tables.

The CR23X contains a comprehensive set of measurement, processing, and output instructions for programming the datalogger. Measurement instructions specific to bridge configurations, voltage outputs, vibrating wire sensors, SDI-12 sensors, thermocouples, Synchronous Devices for Measurement (SDMs), and multiplexers are standard. Processing instructions support algebraic, statistical, and transcendental functions for on-site processing. Output instructions control external devices and process data over time. These instructions include averages, maximums, minimums, standard deviations, histograms, and FFTs.

The maximum rate the CR23X can execute its program is 100 times per second. The maximum rate a single input can be measured is 1,500 samples per second. A battery-backed clock assures accurate timekeeping.

Input/Output Connections

Analog Inputs

Twenty-four single-ended (12 differential) channels measure voltage levels with 15-bit resolution on five software selectable voltage ranges.

Pulse Counting Channels

The CR23X has four 8-bit (two 16-bit) pulse channels for measuring switch closures, low-level ac pulses, and high frequency pulses.

Digital Input/Output Ports

The CR23X has eight digital input/output control ports. All of the ports can be used for output control and to sense the status of external devices. Three of these ports can read SDM peripherals and four of them can be configured as pulse counters or interrupt inputs.

Continuous Analog Outputs

Two continuous analog outputs with 15-bit resolution provide voltage levels to strip chart recorders or proportional controllers.

Switched Excitation Outputs

Four outputs provide precision excitation voltages for resistive bridge measurements. The excitation is programmable over a ± 5000 mV range.

Power Connections

The continuous 5 V and 12 V terminals are for connecting sensors and non-CSI peripherals. The switched 12 V terminal is program controlled.

Cover photos (CR23X applications): From top, Eddy covariance systems, Automotive performance testing, Weather station installation, Geotechnical monitoring.

Battery Base Options

The alkaline base option includes 10 D-cell batteries with a 10 Ahr rating at 20°C. The rechargeable base option provides an internal 7 Ahr sealed rechargeable battery that can be trickle-charged via vehicle power, solar panels, or ac power. For charging the battery via ac power, a 110 Vac wall charger is offered for US customers or other countries with 110 Vac outlets. A 100 to 240 Vac wall charger is also available. When using vehicle power, our DCDC18R Boost Regulator is used to increase the vehicle's supply voltage to charging levels required by the CR23X. The low-profile (no battery) option requires a user-supplied dc source. It is preferred when the system's power consumption, (e.g. satellite transmitters) needs a user-supplied deep-cycle battery or when it's advantageous to have a thinner datalogger.

Peripherals and Software

CR23X-based systems typically include a data retrieval option and may include measurement and control peripherals. Our software supports datalogger programming, communications between the CR23X and PC, and data display.

Data Storage and Retrieval Options

Storage Modules reliably store data and datalogger programs. The data and programs can be downloaded later to a PC.

Direct Links use the CR23X's RS-232 port to connect the datalogger to a computer. The CR23X can be connected to the computer over distances up to 50 feet.

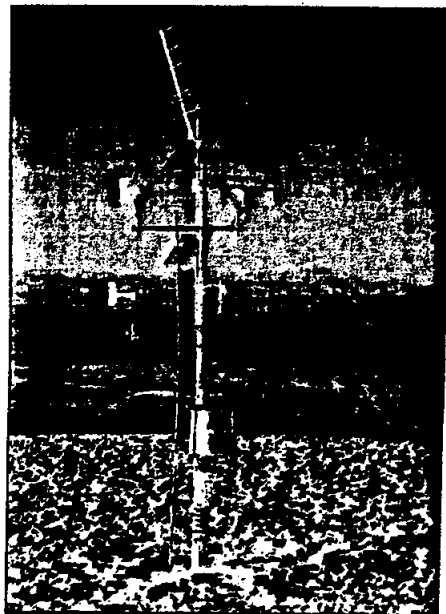
Short Haul Modems provide local communications between the CR23X and a PC with an RS-232 serial port.

Multidrop Interfaces link a central computer and up to 200 dataloggers on a single coaxial cable.

PDA Handhelds can communicate with the CR23X via a serial cable and PConnect Software.

Ethernet Communication Peripherals allow the CR23X to communicate over a local network or the Internet.

A GOES satellite system provides data retrieved from a weather station on Nevado Sajama, Bolivia, to climate researchers in the United States.



Transient Protection

Rugged gas tubes protect the analog inputs from electrical transients. The CR23X is CE Compliant under the European Union's EMC Directive.

Operation in Harsh Environments

Standard operating range is -25° to +50°C; an extended range of -40° to +80°C is available. A CR23X housed in a weather-resistant enclosure with desiccant is protected from humidity and most contaminants.

Radio Frequency (RF) Communications are supported via UHF, VHF, or spread spectrum radios.

Telephone Networks use landlines or cellular transceivers for communications between the datalogger and PC. Our voice-synthesized modem transmits the CR23X's data by voice.

Satellite Transmitters transmit data via the GOES, Argos, or INMARSAT-C satellite systems.

Channel Expandability

SDMs and multiplexers expand the already formidable measurement and control capabilities of the CR23X. SDMs are addressable peripherals that expand digital control ports, analog output ports, and measurement capabilities. Multiplexers allow sharing of switched excitation channels and analog inputs, thereby increasing the number of sensors that can be measured. Several SDMs or multiplexers can be connected to one datalogger.

Software Packages

PC200W Starter Software allows you to transfer the datalogger's program and collect data via a direct communications link. PC200W is available at no charge from <http://www.campbellsci.com/resource.html>

LoggerNet and PC208W are our full-feature software packages. They support:

- Direct and telecommunications links
- Datalogger programming for most commercially available sensors, SDMs, multiplexers, and relays
- Real-time data display
- Report generation

Real-Time Data Monitor (RTDM) allows experienced users to create custom graphic screens. RTDM supports automatic generation of JPEG output for Internet display. A similar software package, RTDMRT, was developed for customers who require display-only capability. RTDMRT allows you to display screens that were created using RTDM.

CR23X Specifications

Electrical specifications are valid over a -25° to +50°C range unless otherwise specified; non-condensing environment required. To maintain electrical specifications, Campbell Scientific recommends recalibrating dataloggers every two years.

PROGRAM EXECUTION RATE

Program is synchronized with real-time up to 100 Hz. Two fast (250 μ s) single-ended measurements can write to final storage at 100 Hz. Burst measurements to 1.5 kHz are possible over short intervals.

ANALOG INPUTS

DESCRIPTION: 12 differential or 24 single-ended, individually configured. Channel expansion provided through AM16/32 or AM416 Relay Multiplexers and AM25T Thermocouple Multiplexers.

ACCURACY: $\pm 0.025\%$ of FSR, 0° to 40°C
 $\pm 0.05\%$ of FSR, -25° to 50°C
 $\pm 0.075\%$ of FSR, -40° to 80°C; (-XT only)

Note: ± 5 μ V offset voltage error is possible with single-ended (SE) measurements.

RANGES AND RESOLUTION:

Input Range (mV)	Resolution (μV) Diff. SE	Accuracy (mV) (-25° to 50°C)
± 5000	166 333	± 5.00
± 1000	33.3 66.6	± 1.00
± 200	6.66 13.3	± 0.20
± 50	1.67 3.33	± 0.05
± 10	0.33 0.66	± 0.01

INPUT SAMPLE RATES: Includes the measurement time and conversion to engineering units. Differential measurements incorporate two integrations with reversed input polarities to reduce thermal offset and common mode errors. Fast measurement integrates the signal for 250 μ s; slow measurement integrates for one power line cycle (50 or 60 Hz).

Fast single-ended voltage:	2.1 ms
Fast differential voltage:	3.1 ms
Slow single-ended voltage (60 Hz):	18.3 ms
Slow differential voltage (60 Hz):	35.9 ms
Fast differential thermocouple:	6.9 ms

INPUT NOISE VOLTAGE: Typical for ± 10 mV input range; digital resolution dominates for higher ranges.

Fast differential:	0.60 μ V rms
Slow differential (60 Hz):	0.15 μ V rms
Fast single-ended:	1.20 μ V rms
Slow single-ended (60 Hz):	0.30 μ V rms

COMMON MODE RANGE: ± 5 V

DC COMMON MODE REJECTION: >100 dB

NORMAL MODE REJECTION: 70 dB @ 60 Hz when using 60 Hz rejection

SUSTAINED INPUT VOLTAGE WITHOUT DAMAGE: ± 16 Vdc max.

INPUT CURRENT: ± 2.5 nA typ., ± 10 nA max. @ 50°C

INPUT RESISTANCE: 20 Gohms typical

ACCURACY OF BUILT-IN REFERENCE JUNCTION THERMISTOR (for thermocouple measurements):

$\pm 0.25^\circ\text{C}$, 0° to 40°C
$\pm 0.5^\circ\text{C}$, -25° to 50°C
$\pm 0.7^\circ\text{C}$, -40° to 80°C (-XT only)

ANALOG OUTPUTS

DESCRIPTION: 4 switched, active only during measurement, one at a time; 2 continuous.

RANGE: Programmable between ± 5 V

RESOLUTION: 333 μ V

ACCURACY: ± 5 mV; ± 2.5 mV (0° to 40°C)

CURRENT SOURCING: 50 mA for switched; 15 mA for continuous

CURRENT SINKING: 50 mA for switched, 5 mA for continuous (15 mA for continuous with Boost selected in P133).

FREQUENCY SWEEP FUNCTION: The switched outputs provide a programmable swept frequency, 0 to 5 V square wave for exciting vibrating wire transducers.

RESISTANCE MEASUREMENTS

MEASUREMENT TYPES: The CR23X provides ratio-metric measurements of 4- and 6-wire full bridges, and 2-, 3-, and 4-wire half bridges. Precise, dual polarity excitation using any of the 4 switched outputs eliminates dc errors. Conductivity measurements use a dual polarity 0.75 ms excitation to minimize polarization errors.

ACCURACY: $\pm 0.02\%$ of FSR ($\pm 0.015\%$, 0° to 40°C) plus bridge resistor error.

PERIOD AVERAGING MEASUREMENTS

DESCRIPTION: The average period for a single cycle is determined by measuring the duration of a specified number of cycles. Any of the 24 SE analog inputs can be used. Signal attenuation and ac coupling are typically required.

INPUT FREQUENCY RANGE:

Signal peak-to-peak ¹ Min.	Max.	Min. Pulse w.	Max. Freq. ²
500 mV	10.0 V	2.5 μ s	200 kHz
40 mV	2.0 V	10 μ s	50 kHz
5 mV	2.0 V	62 μ s	8 kHz
2 mV	2.0 V	100 μ s	5 kHz

¹Signals centered around datalogger ground

²Assuming 50% duty cycle

RESOLUTION: 12 ns divided by the number of cycles measured

ACCURACY: $\pm 0.03\%$ of reading

PULSE COUNTERS

DESCRIPTION: Four 8-bit or two 16-bit inputs selectable for switch closure, high frequency pulse, or low-level AC. Counters read at 10 or 100 Hz.

MAXIMUM COUNT RATE: 2.5 kHz and 25 kHz, 8-bit counter read at 10 Hz and 100 Hz, respectively; 400 kHz, 16-bit counter.

SWITCH CLOSURE MODE:

Minimum Switch Closed Time: 5 ms
Minimum Switch Open Time: 8 ms
Maximum Bounce Time: 1 ms open without being counted

HIGH FREQUENCY PULSE MODE:

Minimum Pulse Width: 1.2 μ s
Maximum Input Frequency: 400 kHz
Voltage Thresholds: Count upon transition from below 1.5 V to above 3.5 V at low frequencies. Larger input transitions are required at high frequencies because of input filter with 1.2 μ s time constant. Signals up to 400 kHz will be counted if centered around ± 2.5 V with deviations $\geq \pm 2.5$ V for ≥ 1.2 μ s.
Maximum Input Voltage: ± 20 V

LOW LEVEL AC MODE:

Internal ac coupling removes dc offsets up to ± 0.5 V.
Input Hysteresis: 15 mV
Maximum ac Input Voltage: ± 20 V
Minimum ac Input Voltage:
(Sine wave mV RMS) Range (Hz)
20 1.0 to 1000
200 0.5 to 10,000
1000 0.3 to 16,000

DIGITAL I/O PORTS

DESCRIPTION: 8 ports selectable as binary inputs or control outputs. Ports C5-C8 capable of counting switch closures and high frequency pulses.

HIGH FREQUENCY MAX: 2.5 kHz

OUTPUT VOLTAGES (no load): high 5.0 V ± 0.1 V;
low < 0.1

OUTPUT RESISTANCE: 500 ohms

INPUT STATE: high 3.0 to 5.5 V; low -0.5 to $+0.8$ V

INPUT RESISTANCE: 100 kohms

SDI-12 INTERFACE SUPPORT

DESCRIPTION: Digital I/O Ports C5-C8 support SDI-12 asynchronous communication; up to ten SDI-12 sensors can be connected to each port. Meets SDI-12 Standard version 1.2 for datalogger and sensors mode.

CE COMPLIANCE (as of 03/02)

STANDARD(S) TO WHICH CONFORMITY IS DECLARED:

EN55022: 1995 and EN61326: 1996

EMI and ESD PROTECTION

IMMUNITY: Meets or exceeds following standards:

ESD: per IEC 1000-4-2; ± 8 kV air, ± 4 kV contact discharge

RF: per IEC 1000-4-3; 3 V/m, 80-1000 MHz

EFT: per IEC 1000-4-4; 1 kV power, 500 V I/O

Surge: per IEC 1000-4-5; 1 kV power and I/O

Conducted: per IEC 1000-4-6; 3 V 150 kHz-80 MHz

Emissions and immunity performance criteria available on request.

CPU AND INTERFACE

PROCESSORS: Hitachi 6303; Motorola 68HC708 supports communications.

PROGRAM STORAGE: Up to 16 kbytes for active program; additional 16 kbytes for alternate programs. Operating system stored in 512 kbytes Flash memory.

DATA STORAGE: 1 Mbyte Flash standard.

Additional 4 Mbytes Flash available as an option.

DISPLAY: 24-character-by-2-line LCD

SERIAL INTERFACES: Optically isolated RS-232 9-pin interface for computer or modem. CS 9-pin I/O interface for peripherals such as storage modules or CSI modems.

BAUD RATES: Selectable at 300, 1200, 2400, 4800, 9600, 19.2K, 38.4K, and 76.8K. ASCII protocol is one start bit, eight data bits, no parity, one stop bit.

CLOCK ACCURACY: ± 1 minute per month, -25° to +50°C; ± 2 minutes per month, -40° to +85°C

SYSTEM POWER REQUIREMENTS

VOLTAGE: 11 to 16 Vdc

TYPICAL CURRENT DRAIN: 2 mA quiescent with display off (2.5 mA max), 7 mA quiescent with display on, 45 mA during processing, and 70 mA during analog measurement.

INTERNAL BATTERIES: 10 Ahr alkaline or 7 Ahr rechargeable base. 1800 mAHr lithium battery for clock and SRAM backup typically provides 10 years of service.

EXTERNAL BATTERIES: Any 11 to 16 Vdc battery may be connected; reverse polarity protected.

PHYSICAL SPECIFICATIONS

SIZE: 9.5" x 7.0" x 3.8" (24.1 cm x 17.8 cm x 9.6 cm). Terminal strips extend 0.4" (1.0 cm) and terminal strip cover extends 1.3" (3.3 cm) above the panel.

WEIGHT: 3.6 lbs (1.6 kg) with low-profile base
8.3 lbs (3.8 kg) with alkaline base
10.7 lbs (4.8 kg) with rechargeable base

WARRANTY

Three years against defects in materials and workmanship.

We recommend that you confirm system configuration and critical specifications with Campbell Scientific before purchase.



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Network Link Interfaces

Models NL100 and NL105

The NL100 and NL105 Network Link Interfaces are 10baseT ethernet communication peripherals. The devices allow any Campbell datalogger with an RS-232 or CS I/O port to communicate with a computer using TCP/IP, making it possible to communicate over a local area network or a dedicated Internet connection. The NL105 is identical to the NL100, but adds a T-Link interface for use with our CR9000(C) Measurement and Control System. Software support for the NL100/NL105 is provided by:



Support Software

LoggerNet 2.0 or higher
PC208W 3.2 or higher

LoggerNet 1.1 or higher
PC9000

Dataloggers

Array-based dataloggers (CR10X, CR10, CR510, CR23X, 21X, CR7)

Table-based dataloggers (CR10T, CR10X-TD, CR510-TD, CR23X-TD, CR9000, CR5000)
CR9000, CR5000

Communication rate is dependent on the datalogger; for example, the CR5000 can communicate at rates up to 115,200 bps.

The NL100 mounts directly to the backplate of our environmental enclosures. The NL105 mounts inside a slot in the CR9000 chassis; it also has optional hardware for mounting to the backplate of one of our environmental enclosures. The NL100 may be located several miles from the datalogger by using short-haul modems, RF modems, MD9 multidrop interfaces, etc. The NL100/105 is configured by the user with an IP address via a computer's RS-232 port and terminal emulator software. Once the NL100/105 has a working IP address, subsequent configurations and setting changes are possible via TCP/IP using Telnet (complete instructions are in the NL100 Instruction manual available on our website).

Ordering Information

NL100 Network Link Interface
NL105 Network Link Interface for CR9000(C)

Optional Items — NL100 and NL105

10873 DB9 female to DB9 male cable (6 ft)
13657 Standard DB9 Null modem cable—required to configure the NL100/105 from a PC's RS-232 port (6 ft)
13658 10baseT ethernet cable (7 ft)
13659 10baseT ethernet crossover cable (7 ft)
13947 Wall transformer 12 Vdc 1.0 A with pigtail connects to 12 V and G power terminal on NL100/105 to ac power source (6 ft)

Optional Items — NL105 Only

7954 T-Link RJ45 Cable (10 ft)
13878 Enclosure mounting bracket for NL105



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Specifications

Power: 12 Vdc supplied via 12 V and ground

Current: 130 mA continuous

Temperature Range: -25° to +50°C

EMI and ESD Protection: Meets requirements for a class A device under European Standards

Application of Council Directive(s): 89/336/EEC as amended by 89/336/EEC and 93/68/EEC

Standards to which conformity is declared: EN55022-1: 1995 and EN50082-1: 1992

Dimensions: 9.25" x 4.25" x 1" (23.5 x 10.8 x 2.54 cm)

Weight: 13.3 oz (377 g)



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ENSR, an AECOM company, is a leading worldwide environmental services firm. Founded in 1968, ENSR serves industrial companies and government agencies with consulting, engineering, remediation, and environmental health and safety solutions. ENSR is a recipient of the BP HSSE Diamond Award, Textron Environmental Remediation Partner in Excellence Award, and Environmental Business Journal awards. As an AECOM company, ENSR is part of a global design and management company with 24,000 employees worldwide serving the transportation, facilities, and environmental markets.

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